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THE SURGERY OF THE CHEST

AND

SOME OF THE PROBLEMS

RELATED TO THE

TREATMENT OF ITS PENETRATING TRAUMATISMS
AND THEIR IMMEDIATE COMPLICATIONS.

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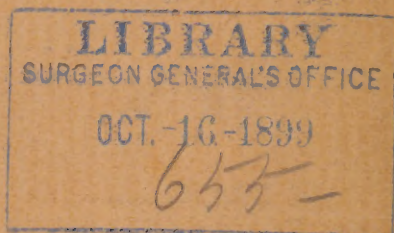


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TREATMENT OF ITS PENETRATING TRAUMATISMS AND THEIR IMMEDIATE COMPLICATIONS.*

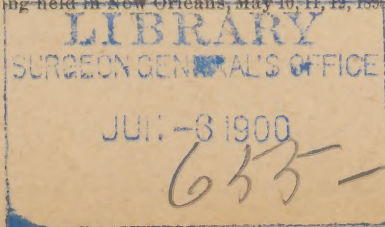
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I.

In selecting the "Surgery of the Chest" with special reference to the treatment of the acute penetrating traumatisms as a subject for special discussion on this occasion, I have been prompted not only by the intrinsic merit of the subject, but also by the impression gathered from many sources that we are now entering a period of unusual activity in this field; an activity which must react most favorably upon the future management of this important class of injuries. It is only necessary to glance at our current literature to realize that the present generation of surgeons are more than ever alive to the growing importance of thoracic pathol-

* The Chairman's Address, Section of Surgery, Louisiana State Medical Society; read at the meeting held in New Orleans, May 10, 11, 12, 1898. Reprinted from the Transactions,



ogy and to the encouraging prospect still offered by this branch of surgery for new and great surgical enterprises. During the last three years scarcely a meeting of national or international importance has been held without the surgery of the chest appearing conspicuously in the foreground. In 1895, Reclus' brilliant address at the French Surgical Congress proved, notwithstanding its modest conclusions, that decided progress had been made in the surgery of the chest since the advent of the Listerian period, an impression that was clearly confirmed by the important discussion that followed. At the meeting of the XIth International Congress held in Rome the previous year, Postemski of Rome presented the collective results obtained by the Italian surgeons in the treatment of diaphragmatic (stab) wounds, and submitted an unprecedented record of recoveries obtained by direct exploration and suture of the diaphragmatic wound and abdominal contents (stomach, colon, spleen, liver, omentum) through a thoracic route made chiefly by Postemski's method (cutting an osteoplastic fenestrum); in all twenty-seven cases of the gravest kind, with only two deaths. Other cases have been since reported of the same character, by Turetta, Nini, Sorrentino, Sorgi, Severeano Frey and Llobet, in which the supra-diaphragmatic route has been adopted, with only two fatalities; and two more successful cases, by Heaton and Bouffleur, in which the diaphragmatic wound has been attacked from the abdominal side, in all a total of thirty-eight cases, thus far, with only four deaths. Certainly a most remarkable showing for this class of injuries, when we consider that in many of them perforation of the stomach or other viscera had occurred with inevitable septic contamination of the pleura and peritoneum.

The brief period from 1895 to 1898 also embraces the heroic epoch in the history of cardio-pericardial traumatology.

The first successful attempt to suture a wounded pericardium (including the ligation of a bleeding internal mammary artery) was recorded by Dalton of St. Louis, in 1895, and was followed by the reports of similar interventions on the

wounded pericardium (stab wounds), by Rieder, of Bonn (1897), Riedel, of Jena (1897), Rhen (1897), and by the Italian cases of Ferraresi, Sironi, Capello, Nicolai (quoted by E. Tassi, *vide Bibliography*), by the author, (reported in Hagen's Thesis, Tulane, 1897, and referred to again in this communication) and by Mansell Moullin, 1897. In all *eleven* operations for wounds of the pericardium with hemorrhage, followed by *five* recoveries and six deaths, none of which can be attributed to the mode of treatment.

The history of the surgical treatment of the wounds of the heart itself in the living, human subject, also begins with 1895. Thus in 1896, Durante reported a case of suture of the wounded heart which Farina, of Rome, had successfully sutured, the patient succumbing seven days later from causes not related to the lesion, the wound in the heart having completely cicatrized (*Archivio ed Atti della Societa Italiana di Chirurgia*, p. xxviii, 1896). Then followed Capellan's case (1896, died second day), Rhen's (1897), and Parozanni's in all of which the patients recovered. (*vide Tassi, Bibliography*). Total, within four years, four cases of suture of the heart itself, with two recoveries.*

In keeping with the spirit and condition that have permitted and justified these daring exploits, the recorded attempts to control the bleeding wounds of the lungs have perceptibly increased within the same period, showing a growing tendency on the part of surgeons to avail themselves of the improvements in the technic with the view of improving the results in this serious class of injuries. What has been done in this direction as far as traumatism of the lung are concerned, will constitute the chief aim of this paper, and we will, therefore, not anticipate our conclusions at this moment.

Any reference to the surgery of the lungs would be incomplete without at least a passing notice of the results accom-

* As this article is going through the press another successful and most interesting case has been reported by Parlavecchio, Rome, in which a punctured wound of the heart was successfully closed with four sutures, July 9, 1898 (Supplemento al Policlinico, August 20, 1898). This would increase the list of sutured wounds of the heart to five, with three recoveries.

plished in the surgical treatment of the pathological lesions of these organs, exclusive of the traumatisms. On this point, it will suffice to quote the statistical summary presented by Tuffier, of Paris, to the XIIth International Congress of Moscow (1897). In this report he tabulated all the accessible cases of lung surgery (*exclusive* of pleural operations) which had been recorded in the literature of the subject up to 1897. He obtained a grand total of 305 operations on the lungs. These he divides into operations for *aseptic lesions* (traumatisms, hernia pulmonalis, pneumocele, neoplasms, hard-tubercular nodules) 29 cases, 22 recoveries=75 per cent. Hydatid cysts 61, recoveries 55 = 90.19 per cent.. *Septic lesions*, (tubercular cavities, abscess, bronchiectasis, foreign bodies, gangrene, actinomycosis, total, 215 cases, 140 recoveries=64 per cent. This statement shows decided progress within the last decade. In 1887, Roswell Park, in a very careful review, had been able to collect only 84 cases of lung surgery as the total record in the literature. Many additions were made to the bibliography by Fabricant in 1894, and by Quinke in 1895, showing by the increasing number of interventions alone that the surgery of the chest was feeling the benign influence of improved conditions as they were evolving to higher planes. In addition to the important contributions and discussions referred to, I would mention *en passant*, the papers contributed by Gaston, Bryant, Fowler and Fergusson, to the American Medical and American Surgical Associations since 1895, as prominent among the American contributions which I can remember at this moment, simply as illustrations of the growing interest—a revival, in fact—in the importance of the chest as a field for new surgical exploration and enterprise.*

*No more striking confirmation of this statement could be quoted than that offered by the recent oration in surgery delivered by Dr. J. B. Murphy, at the Denver meeting of the American Medical Association—a most learned and original contribution which is destined to remain as a permanent landmark in the history of this subject. ("The Surgery of the Lung," Journal American Medical Association, July 25-August 12, 1898, which has appeared since this paper was written, too late, unfortunately, to be available in its preparation).

II.

After the revolution inaugurated by Lister nearly thirty years ago and the expansion of the surgical horizon that followed, the surgery of the splanchnic cavities rose rapidly, as we know, to a position of just and preponderating importance. This progress was most marked in the operative treatment of abdominal and pelvic diseases because the problems to be solved, in the peritoneum, though numerous and varied, were comparatively simple, as the aim of the technic was, chiefly, to prevent hemorrhage, shock and sepsis. In the chest and cranium a far greater anatomical and physiological resistance to intrusion had to be encountered in harmony with the greater importance of the contained organs. Here, therefore, the technical problems to be overcome, have been more complex and difficult; for, in addition to a great sensitiveness to shock and greater liability to fatal hemorrhage and sepsis, the surgeon had to take into account the traumatism required to reach and expose the contained organs. Besides, there was also a grave and special risk, peculiar to this region—that of sudden suppression of lung function from pneumothorax. It is these special dangers that account for the lack of parallelism between the achievements of surgery in the abdomen and in the chest. This accounts for the fact that the injuries and diseases of the pleura, lungs, heart, diaphragm and mediastinum have not been and probably never will be attacked as directly and freely as similar injuries and conditions in the abdomen; and that surgical interventions in the chest will in general, not be followed by that relative benignity in the post operative sequelæ which characterizes the incursions of surgery in the infra-diaphragmatic regions. Mr. Stephen Paget, in his recent learned and charmingly written book on the subject that now interests us, has most convincingly demonstrated “that the record of the last twenty years is wonderful indeed;” but, he adds: “We have gone forward so far and so fast, that what we want now is rather to see more readily and more accurately the indications for operation than to invent new methods of operating.”

We would venture the comment on this statement that it is not so much the capacity to judge of the indications that is at fault with us, or even the plethora of methods of operating, but the ability to meet these indications adequately when we see them plainly before us. It is the means of preventing and neutralizing pain, shock, hemorrhage, asphyxia, infection and exhaustion, that govern the indications and that control our capacity for action and successful application of "methods" in chest injuries and lesions. The means that we now possess to counteract these elementary obstacles to surgical success in many of the emergencies and pathological conditions of the thorax are still imperfect, and are far from representing the maximum of efficiency that we may yet hope to attain. The best proof of this is in the constant improvements that we are making gradually but surely from decade to decade, from year to year, in our technic; which, as it improves, increases the frequency of the indications for operation and widens our sphere of action. Even since Mr. Paget's book was written new investigations of vital importance have appeared; Tuffier and Hallion, Quenu and Longuet, Doyen and others have added experimental and clinical data, which are of the greatest value in strengthening one of the weakest points in our armament when dealing with chest cases, viz.: the means of counteracting pneumothorax and preventing collapse of the lung. From this we gather that we are yet far from attaining the furthest limit of our legitimate aspirations in this branch of surgery; and, while we recognize its limitations, we must persevere in the endeavor to improve upon our present records until we touch the line drawn by the demands of absolute physiological and anatomical necessity. With this conviction as a guide and the belief that the treatment of penetrating wounds and their complications will best exhibit the progress accomplished in the lines upon which we may expect to advance, I shall begin by considering the influence of asepsis on the surgery of the chest.

III.

To adequately answer the question: What has been the influence of Listerism on the progress of thoracic surgery,

would compel a review of the history and regeneration of all surgery since Lister first demonstrated the importance of Pasteur's discoveries, nearly thirty years ago. With Lister began the evolution of our present methods of wound treatment in the chest, as elsewhere; after him, bacteriology has continued to increase our knowledge of microbic pathogeny, so that not only have our conceptions of the causation and pathology of the great thoracic infections been radically transformed, but our methods of diagnosis, prognosis and treatment have completely changed for the better, as well.

Thirty years ago the word "infection" was a mystery, and the meaning of pus and suppuration, as biological reactions, was unknown. Twenty years ago the word Empyema summed up, in itself, a disease and a diagnosis; now it is a simple inflammatory phenomenon, the result of a variety of pyogenic bacterial invasions. Ten years ago it was only necessary to find pus to determine the indication for operation; now we question the causes of the suppuration, and, according to its origin, whether tubercular, pneumococcal, staphylococcal, streptococcal, saphrophytic, or other, we modify our prognosis and our methods of operating.

From bacteriology we have also learned facts of practical importance which have greatly influenced our attitude toward chest injuries in late years. We have learned that the bacterial flora of the respiratory passages rapidly diminishes as we approach the bifurcation of the trachea and is practically extinct in the smaller bronchial tubes. This accounts for the comparatively innocent results that follow the penetrating wounds of the pleura and lungs, in which pneumothorax is the chief consequence. Pneumothorax from a perforated lung (previously healthy) rarely leads to infection of the pleura because the air that escapes through its parenchyma is germless and consequently harmless. We have learned to fear infection from the external wound, and then only when germ-laden foreign bodies, wadding, clothing, etc., enter with the missile or soiled weapon. This is the foundation for the antiseptic treatment of chest wounds, which forbids all unnecessary probing, which removes contaminated foreign

bodies when these are recognizable, which endeavors to sterilize the skin and external wound and seals the wound openings.

That other equally important factors account for the greatly lessened mortality of modern wounds, especially the gunshot wounds of the chest, no one will deny; but these better results are due not only (as we shall see later) to the diminished infectiousness of modern missiles, but to the prevention and treatment of the post-traumatic infections. The success that has attended the modern treatment of these injuries attests to some beneficent change in the mode of treatment even when primary infection has unavoidably occurred with the traumatism. In what does this change consist? Simply in the *greater promptness* with which the surgeon lends his aid the moment that the signs of infection manifest themselves. We do not wait now until the patient's vitality has been entirely sapped by prolonged saturation with microbial toxins, and until the chest cavity has been transformed into a vast pus-chamber, but we operate early and courageously, having learned that in the prompt evacuation and complete drainage of septic products, we have applied the most powerful of germicides. And all this has come to us through the confidence gained in the application of Listerian principles; in the knowledge that it is possible for us to protect our patients and guard our own acts so that we are certain not to add new agents of evil to those pre-existing.

We are told that Hippocrates clearly taught and successfully practised the operation of Empyema. He fearlessly and promptly attacked purulent collections in the pleura by free incision, trephining of ribs and drainage. But, as Paget remarks, "His Art, like all Greek art, was lost. * * * What Hippocrates could do in the pure air of Greece, with his clean methods of operating, was fatal when it was done in a mediæval hospital, or in the infected wards of the hospitals one hundred years ago.

"The doctrine that puncture for serous effusion would convert it into a purulent collection, and that the entry of a few

air bubbles into the pleura might set up a fulminating supuration, blocked the way; and blocked it still might be, but for Lister."

How true this is, is also clearly told by Mr. Paget, in the following paragraphs:

"For example, as late as 1882, M. Bouchut published as an instance of good and profitable surgery, a case of empyema in a boy aged 9, cured in sixteen months, after fifty-eight punctures. Gimbert, in a child 11 years old, made seventy-four punctures in nine months, obtaining a grand total of thirty pints of pus. And the worst of it all is, that out of forty-eight patients thus tormented, only six were cured.

"Nor did free incisions, before Lister, fare much better. Out of twelve cases, under the care of Velpeau, not one recovered. Of fifty cases, under the care of Dupuytren, all but two died. Sir Astley Cooper, with all his vast experience, complained that he 'could never get a single cure.'"

No wonder that when Dupuytren was himself stricken with empyema, and the operation was proposed, he consistently refused, exclaiming that he would "rather die by the hand of God than that of man."

Terrier says that the results of pleurotomy for empyema were so discouraging as late as 1869 that when Nélaton was called upon to operate upon his colleague, Professor Dolbeau, for the relief of a purulent collection in the chest, this distinguished surgeon (Nélaton) proceeded to rehearse the operation on the cadaver as he had never performed it before (in Terrier's belief) upon the living subject.

Fortunately, to Nélaton's credit be it said, Dolbeau proved an exception to the rule, and he recovered.

Moutard Martin, with free pleurotomy, but imperfect asepsis, was regarded as a most successful and fortunate operator in 1872, when he reported a loss of only 31 per cent. of his empyemas. With greater improvement in aseptic methods, no irritant or toxic irrigations into the pleura, but better drainage, better differentiation of cases, and, above all, earlier operations, Cabot was able to present a series of cases in 1885 with only 15 per cent. mortality (Bouvèret).

But again, quoting from Paget's admirable chapter on this subject, "our estimate of the mortality from empyema must vary according as we include or exclude the numerous troubles that are more or less a part of it. Bouveret, in 1888, collected 175 cases, with 55 deaths; Koenig, in 1891, published his 76 cases, with only 10 deaths; Hofmokl (1889), of his 60 cases, lost 28, but of these no less than 13 died of tubercular disease; 6 of pneumonia, 3 of pericarditis, 3 of peritonitis and 1 each amyloid disease, heart failure and malignant disease. Foltanek, in 1891, published 21 cases of empyema in children, treated by incision without resection, with only 4 deaths. Immermann (1890), of his 74 cases, lost 20; but 17 of the 20 died from tubercular disease or septic infection, or other causes than empyema itself. Dr. Lewis Marshall (1895) gives 45 cases, at all ages, with 7 deaths; Dr. Cantley (1895) gives 84 cases, all children, with 14 deaths; Mr. Pitts gives two lists—86 cases, at all ages (St. Thomas Hospital, 1880-1892), with 20 deaths, and 214 cases at Great Ormond street during the same period, and 39 deaths. It is the complications of the disease that drive its death rate up still to 15 or 20 per cent.; were it not for these one might reckon it at 10 to 12 per cent. From the etiological point of view the tubercular are the most fatal; the metapneumonic the most benign." Of this last variety, I have operated in the last three years, in private and hospital practice, 9 consecutive cases (sequels of grippe and pneumonia) without fatal results, and all but one made rapid recoveries. In traumatic empyema, which is usually of a mixed staphylo- and streptocogenic type, though very often complicated with saprophytes (putrid empyema), the conditions are more serious and the mortality greater. But even here it will suffice to quote Schede's (1890) magnificent results in this class of cases: "Out of nineteen cases, 5 suppurated; 3 out of 11 knife wounds, and 2 out of 8 gunshot wounds; and of all 19, only 1 died. What more eloquent argument in favor of the superiority of modern methods when applied by a master!

IV.

But if the introduction and application of asepsis has shorn the pleura, to a large extent, of one of its greatest terrors—septic infection—it has also proved most beneficial in encouraging the perfection of the purely operative technic, which it has transformed in a manner that to the surgeons of the past generation must appear short of the miraculous. If the dangers of sepsis appeared insurmountable, the anatomical barriers in the way of the complete exploration and drainage of the chest that were offered by the osseous frame-work of the thorax—*i. e.*, the ribs, the sternum, and the vertebræ—must have appeared to the older operators equally formidable.

Nevertheless, the last decade has witnessed the gradual and progressive demolition of these apparently fixed obstacles until the gateway to the thorax can now be opened so wide that scarcely an organ contained within its walls could possibly escape from intrusion.

We have noticed that in the Hippocratic days ribs were trephined to evacuate pus, but this practice was soon forgotten; then, after centuries of inactivity, came tentative punctures with trocars, aspirations, incisions, and *again* trephinings; then resections of single ribs.

But the persistence of thoracic fistulæ in cases in which pleurotomy was performed as a late operation, for empyema, led to the resection of *several* ribs, and with this began a new epoch of unprecedented boldness in attacking the thoracic parieties. It was in 1876 that Estlander, of Helsingfors, published the results of his operation for the cure of thoracic fistula and he advocated the multiple resection of ribs to favor the sinking in of the chest wall and the obliteration of the pleural cavity. His predecessors, Roser, Simon, Peytavin, Schneider, De Cernville, but more particularly Gayet and Letievent, had already applied this procedure independently but not systematically as Estlander. As a result we find that in 1883, Berger had reported twenty-seven cases in which multiple resections had been made for the relief of permanent thoracic fistula, and of these hitherto hopeless cases ten had

completely recovered and five improved. Soon modifications followed, involving much greater, bolder and more serious attacks upon the osseous frame-work, finally culminating in Max Schede's extensive thoracoplasty, which in many instances involved the entire thickness of the chest wall, including the extirpation of the thickened and diseased pleura.

Schede's operation, which amounts practically to a hemi-resection of the thorax, unquestionably sums up the maximum of surgical traumatism that it is possible to apply with any expectation of tolerance, to the chest walls and pleura. In some of Schede's cases, every rib, from the second to the ninth and sometimes the first, and part of the clavicle, were resected, including the costal cartilages, in front, to the scapula, behind. By this procedure not only is the entire pleura exposed, but it is totally excised and the whole chest wall on the affected side is effaced and is reduced to a mere musculo-cutaneous flap which is utilized to cover the huge cavity left by the permanently compressed lung. In spite of this immense traumatism, six out of seven, otherwise hopeless cases last reported by Schede, in 1890, completely recovered with excellent functional results as regards the use of the upper extremity and without curvature of the spine. Since then almost equally favorable results have been obtained by other surgeons.

Other modifications of Estlander's multiple rib resection have been proposed and practised by Boeckel, Quenu, Boiffin, Delagenière, Délorme, Gaston and others. These are of less severity than Schede's thoracoplasty, but their ultimate object with the exception of Délorme's operation is the same, namely: to obliterate the pleural cavity by demolishing or breaking the costal arch. Délorme's principle, which is quite different from that of other operations, has not been tested sufficiently to permit of a final expression of opinion as to its practical merits. It is worthy of consideration, however, as a departure in the right direction. This operation aims at the "decortication" of the collapsed lung, which is imprisoned in a thick, tough, shell of organized exudation, which holds it packed permanently in the costo-vertebral groove. To accomp-

lish his purpose, Dèlorme makes a trap door, osteoplastic flap, in the chest-wall, large enough to allow easy inspection of the interior and to permit the entire hand to penetrate into the thorax. By this means he peels off the thickened capsule of the pleura and liberates the incarcerated lung, which gradually expands and obliterates the pleural cavity by coming in opposition with the chest-wall.

Of course, this method as well as all the others mentioned, have their special indications and limitations. Dèlorme's method is very seductive in principle, but the reports of cases thus far operated by this procedure (not more than a dozen, since it was practised by Dèlorme for the first time in 1892) are not sufficient to establish the final *practical* value of this theoretically ideal procedure.*

V.

In addition to these extensive methods of lateral thoracoplasty which aim solely at the radical cure of empyema and persistent fistula after pleurotomy, there are other bolder and more hazardous procedures, still in their infancy, which are intended to open up large routes of entrance into the anterior and posterior mediastinal spaces of the chest. They are of interest to us in this connection simply to confirm the statement previously made—*i. e.*, that to the resources of modern surgical technic, the resisting frame-work of the chest—with the single exception of the vertebral column—can offer no serious obstacle. Beginning anteriorly, we will note that the sternum has been more or less successfully and repeatedly removed as a whole or in part for tuberculosis or neoplasms.†

* This procedure is again considered in connection with insufflation of the lung with the Fell-O'Dwyer apparatus.

† Mazzoni, Koenig, Quester, Pfeiffer, Bardenheuer, Glück, Budon, R. Park, Graves, Bayer, have performed total sternectomy for neoplasms, in all 11 cases with 4 deaths, or 48 per cent. mortality (Des tumeurs du squelette thoracique, by MM. Quenu and Longuet, Rev. de Chirurgie, May 10, 1898). Other cases of partial sternectomy have been reported by Professor Keen and others, including the writer, which are not mentioned as of less significance from our present point of view. Total and partial sternectomy for tubercular disease has been performed quite frequently, but it is a much less serious operation than when performed for malignant disease. In removing the bone for tubercular disease the mediastinum is, as a rule, rarely invaded; the thickened periosteum usually remains as an effective barrier which prevents infection or injury to the retro-sternal organs and tissues.

A systematic operation for invading the anterior mediastinum has been recently proposed and successfully carried out in the living subject, in at least one case, by Mr. Milton, of the medical school of Cairo, Egypt. ("Mediastinal Surgery," *Lancet*, London, March 27, 1897, 1. 872-875.) He opens the anterior mediastinum by what he describes as the "median, normal, thoracic incision." It consists essentially in (1) a long skin incision extending from the thyroid cartilage to the base of the ensiform. (2) Exposure of the trachea to the supra-sternal notch and the anterior surface of the sternum. (3) Detachment of the cervical fascia from the supra-sternal notch, keeping close to the periosteum. (4) Separation with the finger tips of the posterior surface of the sternum just below the notch from the tissues lying beneath it (innominate artery, veins, trachea and nerves), which are displaced backward. (5) An incision with the saw along the middle line of the sternum from notch to ensiform cartilage, not implicating the latter, and quite cutting through the whole thickness of the bone. The sawing of the sternum may be commenced at either the ensiform end or the supra-sternal notch. After sawing through the sternum, the two halves are pulled apart with strong hook-retractors, helped by a blunt chisel, which also cuts through any undivided portion. Firm traction on both halves of the sternum is sufficient to separate them one centimeter. If the posterior sternal ligaments are divided the two halves of the sternum can be separated to the extent of four or five centimeters and the anterior mediastinum can be thoroughly exposed. After this has been done the trachea can be exposed by the finger down to its bifurcation, and the innominate artery and veins, the heart, pericardium, pleuræ and vessels at the root of the heart also become easily accessible. Milton tried this procedure on a goat. He was able to verify its value as a route to the mediastinum quite satisfactorily notwithstanding the fact that both lungs collapsed from a tear in the pleuræ which in this animal communicate normally with one another. He was also able to demonstrate that by intra-tracheal insufflation through a canula attached to a bellows,

the collapse of the lung could be overcome and artificial respiration successfully maintained until he had closed the tear in the pleura and finished a most thorough exploration and manipulation of the heart itself. After completely closing the pleura and pericardium, the osseous halves of the sternum were approximated. The animal recovered very quickly from this operation. Mr. Milton operated on an Egyptian fellah, on January 25, 1897, and removed the entire sternum and a mass of retro-sternal mediastinal glands by this method. Costal respiration ceased on division of the sternum, but abdominal breathing was good throughout. After removing the sternum, the pleuræ, pericardium, trachea and innominate vessels were freely exposed. The patient recovered from the operation, and shortly after, the ribs rapidly came together and the gap was obliterated. Apart from the difficulty experienced in coughing and expectorating, there were no very distressing sequelæ to the operation. I have referred to this operation at some length, because, notwithstanding its heroic character, it is the simplest thus far offered for obtaining access to the mediastinal space, and promises to be of service in dealing with foreign bodies in the trachea and other conditions in which experience has shown that the posterior mediastinal route is most difficult and dangerous. Its successful application in future will also be very materially assisted by application of artificial respiration by the intra-laryngeal apparatus, to be described later on, which will prevent asphyxiation should the abdominal respiration be insufficient, or should the lungs collapse from accidental tears in the pleuræ.

Nosiloff (1888), Quenu and Hartmann (1891), J. D. Bryant, (1895), McF. Gaston (1896), have described special dissections for the systematic invasion of the posterior mediastinum which are now familiar to all students of surgery. While the posterior mediastinum has always been regarded in the light of the holiest sanctuary of the thorax, and has thus far practically defied all systematic exploration in the living, it is interesting to note that the surgical mind has not ceased to think of the possibilities of the *art* in this dread region. In

fact, it is not unreasonable to expect that with the help of the new suggestions by which the aerating function of the lungs can be maintained while operations are progressing in the chest, it may be soon quite feasible to utilize the anterior and posterior mediastinal routes to evacuate the gangrenous or purulent collections of septic mediastinites from perforated esophagus; for the removal of foreign bodies in the esophagus; neoplasms, etc.

VI.

Thus far we have considered only two of the important elements which have barred the way to the successful intervention of surgery in the treatment of the injuries and diseases of the chest, namely, pleural sepsis and the mechanical difficulties offered by the rigid frame-work of the thorax formed by the sternum, ribs and the vertebræ. We have gone at some length to show that to the surgeon of the present who has been properly trained in the principles of asepsis and who has been schooled in the operative manual these obstacles are of comparatively little moment. With anesthesia and modern instruments there can be no mechanical difficulty in promptly and securely opening up a large and easy avenue into almost any portion of the thorax. But to the mere mechanical success of the intervention are opposed, at least, three other factors for evil which are infinitely more uncertain and uncontrollable, summed up in the words, shock, hemorrhage, and asphyxia—the last resulting from the sudden development of acute traumatic pneumothorax. How to deal with these conditions, how to prevent them and how to remedy them when they already exist, constitutes the quintessence of the surgical therapeutics of the thorax. In fact it may be safely stated that the future evolution of the surgery of the chest will depend almost entirely upon the success with which these gravest of conditions will be met.

VII.

That the sudden admission of air into the normal, healthy pleura, whether it occur accidentally or as the result of deliberate purpose, in the course of an operation on the chest, is

often a source of great peril to the patient and always of profound anxiety to the operator, can not be doubted. It is not, of course, as was feared in the days of old, that there is any risk of contamination from the air itself; nor is it because a little air has entered and there is perhaps a *partial* collapse of the lung, but it is because of the great shock with cyanosis and other evidences of defective oxygenation of the blood—often culminating in death on the operating table—which follow when a *large* opening is made in the pleura—that has led the surgeons of all times to dread the production of traumatic or surgical pneumothorax as a great evil.

The entire catalogue of experiments on the lower animals for the purpose of studying the possibilities of lung surgery proves that one of the most serious obstacles to successful experimentation is the great mortality among animals from the immediate, often instantaneously fatal, effects of air in the pleura and pulmonary collapse. These experiments have proved that while it is quite possible for animals to live with only one lung the operation is of the gravest possible character and fails either primarily from the shock of the pneumothorax or secondarily from septic causes. Glück, for instance, who operated in 1881, performed pneumotomy on six dogs and fourteen rabbits; only two of the latter survived and all of the dogs died. There was always immediate cyanosis upon entering the pleura, and death, in the majority of the the animals, was from this cause. The same kind of evidence is furnished by Block (1881), Marcus (1881-82), Schmid (1881), and Biondi (1882), whose experiments were by far most successful, scientific and complete. He notes that the general mortality was chiefly from this cause. For instance, he operated on five dogs and lost four, death occurring immediately upon opening the thorax or following a few hours after—without any apparent cause other than dyspnea and apnoea. The same testimony with a few variations is furnished by Zakharwitch, De Forest Willard, W. Le Moyne Wills, Pourrat and Rodet, by Tuffier (1896), and by the last contributors on the subject—Quenu and Longuet (1896). They state that “in fifteen of our experiments in which the

pleura was opened freely we constantly observed an intense dyspnea; twelve of these dogs died of asphyxia while on the operating table, or five minutes after, death coming on in a manner that completely excused the anesthetic. But in some dogs the opening of the pleura is a much graver procedure than in others, or than in man, on account of an anatomical peculiarity which had been first referred to by Block, and is again insisted upon by Quenu and Longuet, namely, the free communication that exists, as a normal condition, between the pleuræ, at a point over the tendinous centre of the diaphragm where the two serous sacs meet. All of these animals infallibly die when the pleura is opened, for obvious reasons. This is a fact which can not be overlooked in animal experimentation. Nevertheless, whether this communication exists or not, acute pneumothorax in dogs and other lower animals is always a condition of the most serious character.

VIII.

That in man acute traumatic pneumothorax, with pulmonary collapse and its attendant shock and asphyxia, is the rock that obstructs the otherwise open channel of the thorax, is also abundantly proven by clinical demonstration and experience; though it must be admitted that there are, at times, exceptional examples of tolerance that are surprising.

With the exception of a few instances that are scattered here and there in the literature of surgery, the deliberate opening of the uninjured or normal pleura for the relief of intra-thoracic conditions or in the course of the extirpation of parietal neoplasms was a thing practically unknown until the middle of this century. A notable exception is that of Riche-
rand, who in 1818 resected three inches of the sixth and seventh ribs with the attached pleura while removing an extensive tumor of the breast. Pneumothorax and collapse of the lung followed with serious respiratory and cardiac disturbances which persisted threateningly for some time, notwithstanding the fact that the opening in the chest was immediately closed with large compresses. That the patient sur-

vived the operation is most creditable to a period when there were neither anesthetics nor antiseptics to help the surgeon.

Dieffenbach's admonition "to stop at the pleura" was religiously observed until comparatively recent years by the vast majority of surgeons when attempting the extirpation of tumors of the thoracic parietes.

"It is curious to notice," says J. Curt,* "how in Germany (where some of the most daring operations of this kind have been performed), the ablest surgeons condemned the removal of the tumors of the chest walls that might involve the pleura.

"Bardeleben, Stromeyer, Albert, Heinecke, pronounced themselves against these operations; Roser recommended long meditation before undertaking the removal of any tumor of the chest that might involve the pleural serosa. Billroth himself in 1887 declared that he was not partial to the extirpation of thoracic neoplasms." Subsequent events have shown that while great progress has been accomplished in a better appreciation and control of septic conditions and better results have been obtained for this reason alone, the dangers from pneumothorax remain practically an unchanged factor in the mortality.

The evidence furnished on this point by Quenu and Longuet, in their very recent and valuable paper on thoracic growths (May, 1898), from which we have gathered the preceding historial data, is very conclusive and to the point. It is based upon the analysis of thirty-four reported cases in which the operations involved the pleura. They classify the manifestations that have been observed by operators whenever the pleura has been opened in thoracic resections, into three categories: (1) Slight manifestations, (2) symptoms of moderate, medium, severity, (3) very grave and fatal manifestations.

1. Among the slight accidents we note irregular respiration and weakening of the pulse (Vautrin). Sudden fall in the pulse—in this case the pericardium was also torn—(Allsberg). Noisy respiration (Tietze).

2. Upon opening the pleura the pulse suddenly weakened and fell; the respiration became so irregular that the anesthetic had to be

* Quoted by Longuet and Quenu.

stopped. After the operation the dyspneic symptoms continued (Fischer and Kolaczek). Maas noticed that when the pleura was opened the pulse at once fell from 80 to 60; became very small and the respiration very slow. Dyspnea persisted in this case ten days. Similar symptoms occurred in Richerand's early case of 1818, already referred to.

3. *Very grave, and at times fatal manifestations.* Liesrinek (1880) opened the pleura and, as he did so, the patient fell into a state of collapse: the pulse became weak and small; the respiration shallow and ineffective: faradization of the phrenic, nevertheless patient succumbed a few days after. Weinlechner (1880) records "that from the moment the pleura was opened the respiration became so labored and irregular that the attendants gave up the patient for dead. He revived a little, but the dyspneic and collapsed state continued until death, which came on a few hours after." Witzel (1890) observes that "with the first tear in the pleura, which was immediately plugged with a tampon, the respiration became accelerated and when the thoracic fenestrum was completed, the dyspnea was so intense and the face turned so blue that for two or three minutes we experienced the greatest anxiety." Vautrin (1891), in another case than that previously referred to, writes that "in tearing the pleura the air rushed in noisily and the operation had to be immediately suspended; the patient fell into repeated syncopal spells and the anesthetic (chloroform) had to be discontinued: The pulse did not rally until five minutes after. Muller (1888) opened the pleura and at once the patient fell into a collapsed state with imperceptible pulse and arrested respiration. The condition was improved when the opening in the chest was closed: but the moment air was admitted, collapse returned. This experience was repeated several times, and always with the same result, until the opening was sealed permanently. Quenu (1896) reported a similar case in which the pulse and respiration failed as shown by spasmodic breathing, cyanosis, "black" tongue, "compelling us to finish the operation in great haste." Not until the pleura had been closed did the breathing improve, though the patient never recovered fully, and died from shock on the third day. Koenig, who has been prominent among the few who regard the fears of surgical pneumothorax as exaggerated, himself lost a patient from this very cause. Tietze (1880) reported a pleurotomy for parietal tumor with fatal results from the same cause, on the second day. Zerubin Ivan (1891), Bardeleben (1890) report alarming symptoms in two cases in which the collapse of the lung was only partial owing to adhesions. C. Bayer (1897) nearly lost a patient while resecting the chest for a tumor, but prevented further collapse by drawing the lung out and suturing it to the chest wall.

Last year my colleague at the Charity Hospital, Dr. F. W. Parham, made a rent in the pleura nearly five inches long while excising an osteo-sarcoma of the ribs (3d, 4th, 5th right ribs). Complete pneumothorax and collapse of the lung, accompanied by alarming and critical symptoms immediately followed. An attempt was made to overcome the collapse and asphyxia by suturing the pleura, which had been separated by previous dissection; but the sutures tore through and thus failed to seal the chest, which was finally accom-

plished by obturating the opening with a musculo-pectoral flap. Gauze packing applied in the wound as a drain also helped to seal it and the patient then improved. Cyanosis and other respiratory symptoms persisted for several hours, but gradually subsided. Convalescence, though slow from sloughing of the flaps, was ultimately followed by complete recovery without serious pleural complications.

The writer has on three occasions, while performing transpleural hepatotomy for abscess of the liver, opened the pleura low down in the chest (after resection of the ninth and tenth ribs) on a level with the lower edge of the lung. Air rushed in, but serious pneumothorax was prevented by plugging immediately with iodoform gauze and then suturing the diaphragm to the chest wall with deep sutures. No bad after effects were observed in these cases.

Tuffier, in relating his experience in the treatment of pulmonary abscess (Intern. Congress of Moscow, 1897, *Chirurgie du Poumon*, p. 11,) brings out all the dangers of pneumothorax in operations on non-adherent lungs in a very strong light. He reports eight cases of septic lesions of the lung (abscess, gangrene, bronchiectasis, tuberculosis, etc.), in which complete pneumothorax occurred during the operation; in two, death was immediate; one died a few hours after the operation; two recovered (suppurating foci not opened); one recovered (focus opened four weeks later). In all, the pneumothorax, from lack of adhesion, was the worst complication and the essential obstacle to successful operation. Doyen, Thiriar, Ohler, Truc and many others could be quoted with narratives that are thrilling with tragic details and narrow escapes from the dangers of acute pulmonary collapse.

IX.

It is the risk of acute pneumothorax that has led surgeons like Krausse and Tuffier to advise the detachment of the pleura to facilitate the *extra*-pleural exploration of the lung, just as the detachment of the peritoneum, to facilitate the extra-peritoneal exploration of the abdominal cavity was advised at a time when the risks of peritonitis were more seriously feared than now. Notwithstanding Tuffier's brilliant

and unique success with this method, which in 1894 permitted him not only to explore but to extirpate a tuberculous apex, the procedure is, as a rule, impracticable. The fear of shock and interference with the respiratory functions will also prevent the general adoption of Bazy's method of direct intrapleural exploration, which this surgeon also adopted with success in 1895.

Bazy makes an incision in the intercostal spaces just large enough to admit the index finger into the pleura. H. Delagenière, with less regard for the risk of pneumothorax, would open the pleura freely for exploratory purposes, depending upon his ability to seize the retreating lung promptly and suturing it to the wound to prevent complete atelectasis. Poirier, Lejars, Ricard, Monod and others have adopted Bazy's procedure with variable results. The advantages of a free and direct intrapleural exploration of the lungs to localize lesions, adhesions and to determine other points, are obvious enough; but such a procedure, no matter how carefully and aseptically conducted, is fraught with risk and will never appear to the general surgeon in the same innocent light that he now regards exploratory laparotomy. *Until the risk of seriously interfering with respiratory function by inducing acute collapse of the lung, is clearly eliminated, or is reduced to a safe minimum, the analogy between the pleura and the peritoneum from the surgical point of view will never exist.*

X.

What is the true nature of the process, or the mechanism, as it were, by which this sudden collapse of the lung gives rise, at times, to such disastrous phenomena as those here recorded? Again, why is it that the sudden free opening of the pleura with complete collapse of the lung, will be followed by only a slightly accelerated breathing, perhaps a little more rapid pulse; and, in others, in apparently identical circumstances, the patients will suffocate, gasp, and often die with the first rush of air into the pleura? These questions remind us of the difficulty we experience in explaining other obscure manifestations of the pleura, notably the peculiar susceptibility or idiosyncrasy, as we might term

the tendency (for want of better name) that some persons manifest to pleural irritation. In many cases of empyema (the vast majority, no doubt), antiseptic irrigation can be applied without bad effects; in others, the injection of mildest and most innocent solutions, even air (Quenu) is followed by shock and terrible circulatory and respiratory disturbances, convulsions, (*pleural epilepsy*, de Cerenville) and even death. And these are not mere accidents and irregular manifestations, but the invariable result of the application of the irritant to the pleural surface of this particular class of patients. It is the fear of these untoward effects, joined to the conviction that antiseptic irrigation of the pleura is unreliable as a means of sterilization that has caused the antiseptic washing of the pleura in empyema to become an obsolete practice in all but putrid cases. These differences are no doubt intimately associated with the variable susceptibility to shock in general, that is displayed by different individuals; some, for instance, who are trained to stand "punishment" can be battered about the chest with impunity others sink in syncope, or in that peculiar state of thoracic shock with shallow breathing which Riedinger has so graphically described under the name of *comotio thoracica*, as the result of a mere fall on the chest. We know that *age* is an important factor in the production of the bad symptom of surgical pneumothorax, and young children are especially susceptible to its disastrous effects. This is no doubt due to the fact that the mediastinal partition that separates the two lungs is very thin movable and compressible. In this way, not only is one lung completely collapsed, but the progressive aspiration of air into the chest through the wound, with the respiratory efforts, ultimately compresses the lung on the uninjured side. The existence of unrecognized adhesions (1) and of lesions in the lung itself (chronic tubercular, pneumonic, fibroid or neoplastic infiltrations, abscess, cavities, etc.) which prevent its collapse, no doubt account for the remarkable freedom from bad symptoms in

(1) These occur according to Panas, in 25 per cent. of all adults (Delorme, *Chirurgie de Guerre*, Vol. 2, 1893.)

many cases. Yet there are a few, inexplicable cases, in which bad respiratory symptoms have followed the opening of the chest when it was evident at the time that adhesions existed and that the collapse of the lung was only partial. (Zerubin Ivan, Bardeleben, Tietze, quoted by Quenu and Longuet). The *size* of the opening and the rapidity with which the air penetrates in the pleura, and the *suddenness* with which the collapse of the lung takes place, are undoubtedly most important factors in determining the gravity and urgency of the symptoms. On these points the evidence furnished by clinical and experimental observation is concurrent and unanimous. The *situation* of the wound has no doubt a decided influence in modifying the symptoms of pneumothorax; though here the testimony of observers is at times contradictory. In a case of nephrectomy reported by Thiriar of Brussels, several years ago, death took place suddenly on the operating table, and before any assistance could be rendered, from an accidental tear in the lower pleural *cul de sac*, followed by immediate collapse of the lung. On the other hand the numerous cases of stab wound of the diaphragm in which the pleura is opened in the lower costo-diaphragmatic *cul de sac*, especially those reported by the Italian surgeons, would lead one to believe that even extensive perforations in this region are not so liable to the bad effects of pneumothorax owing to the close apposition of the diaphragm, which acts as an obturator and prevents a sudden filling of the pleura with air.

The true explanation of the comparative benignity of the pneumothorax in the numerous successful operations (by making large fenestra in the chest) reported by Postemski and his colleagues lies in the fact that in stab wounds of the diaphragm a partial or incomplete pneumothorax is caused by injury itself, which prepares the lung, as it were, for the complete collapse of the lung which occurs when the larger opening is made subsequently, to repair the diaphragmatic injury. There are, nevertheless, a few exceptional cases on record in which large openings have been made in the chest-wall for the removal of rib-tumors, in which the collapse of the lung has been complete, without the occurrence of very

serious or alarming respiratory symptoms (*e. g.*, Vautrin's case). It is very difficult to account for such remarkably good behavior on the part of the patient, and we must explain these differences (for want of better theory) on the ground of a native capacity for resistance to shock and traumatic conditions. Of one thing we are certain, and that is, that the mere suppression of the entire aerating surface of one lung by complete atelectasis is not incompatible with life or with a satisfactory respiratory capacity. Any surgeon of experience who will recall the condition of the lung, as it lies compressed and completely obliterated in a mass of exudate, in cases of chronic empyema, will need no further demonstration to convince him of the truth of these propositions. No experimentation on animals is required to prove a point so clear to all. Furthermore, the sufficiency of one lung for purposes of respiration, apart from other pathological and experimental evidences, is in harmony with the general law of adaptation and compensation so beautifully illustrated by all the dual and symmetrical organs of the body (kidneys, testes, etc.), to call for much question. And yet, it is undeniable that the dangers of acute pneumothorax are due essentially to the sudden suppressing the respiratory function, *i. e.*, to asphyxia. There are cases, exceptional it is true, in which death occurs almost instantly with the first tear in the pleura—too quickly in fact to be due to a simple arrest in the respiration. Such cases remind us of the rare deaths in chloroform and ether narcosis, in which the anesthetic has scarcely had time to reach the larynx when death takes place. These fatalities are so instantaneous that they can be accounted for in no other way than by some form of reflex inhibition of the cardio-respiratory apparatus in the medulla through the agency of irritant centripetal impulses starting in the peripheral nerves. In the majority of cases the fatal termination comes on more gradually, in a few minutes or even hours, which is evidence that the asphyxia is purely mechanical and is due to insufficient oxygenation. In pathological conditions (hydrothorax, empyema, pneumothorax), the element of respiratory shock is eliminated by the *gradual* encroachments

of disease, and an opportunity is given to the respiratory centres, and remaining pulmonary surface of the sound lung, to accommodate themselves to the new conditions. This difference between the *gradual* suppression of lung function and its *sudden* total extinction on the other, is what makes pathological pneumothorax relatively benign, and acute traumatic or "surgeon's" pneumothorax so dangerous. This difference seems to depend on the fact that in the acute total collapse of the lung that is brought about by creating a large aperture in the pleura, not only is the lung on the affected side functionally disabled, but the *opposite* lung, on the uninjured side, is *also* effectually crippled so that it is rendered valueless as far as its oxygenating capacity is concerned. In other words, it would appear that the sudden suppression of one lung would also inhibit the functions of the other, so as to totally arrest the respiratory capacity of *both* organs. If one lung were to maintain its respiratory capacity while the other was collapsed, it is not likely that asphyxia would take place, as the aerating function of one lung is quite sufficient to meet the demands of the organism.

That the sudden "brusque" collapse of one lung will lead to a synchronous arrest of the entire respiratory mechanism is a fact that would appear to be sustained by the experimental study of this phenomenon by the graphic method. Carlet and Strauss (1873), and Gilbert and Roger (1891), studied and first applied the graphic method to the experimental study of pneumothorax, but the most instructive observations are those published by Rodet and Pourrat (*Recherches Experimentales sur le Pneumothorax*, 1892) and in J. Pourrat's thesis (*Contribution à l'étude du Pneumothorax Experimentale par plaies penetrante de poitrine*, Lyons, 1892).

In these experiments complete tracings of the respiratory movements were obtained by using an intra-tracheal canula connected by a bar to a recording tambour on the plan of a Marey's pneumograph. The results obtained when collapse of the lung was produced by making a large fenestrum in the pleura were always the same:

“Immediately upon opening the pleura, the lips of the wound in the chest being kept forcibly open, the respiratory movements increased at first in amplitude; then, after a short phase of acceleration, they become slower * * * producing by an elongation of the pauses and a diminution in the amplitude of the inspirations the final and complete arrest of the thoracic movements and absolute cessation of respiration.” If the external wound was closed and artificial respiration was practised either by external methods or by direct intratracheal insufflation, the breathing could be restored and the animal brought back to life; but in two anesthetized dogs artificial respiration was ineffectual after the first cessation of breathing had occurred. On the other hand, if the external wound was closed promptly, before the thoracic movements had completely stopped, the animal usually recovered.

In concluding their observations Rodet and Pourrat ask themselves: What is the cause of these respiratory troubles? Asphyxia certainly plays an important part in the second phase of these manifestations, but it does not suffice to explain the beginning. Must we account for the symptoms by an inhibition of the respiratory centres caused by the impression produced on the sensory nerves of the pleura by the abnormal ventilation of the serosa? Perhaps this may be the case, but we are inclined to see the explanation in another light. The collapsed lung does not expand, as we have seen; this inertia completely suppresses the normal stimulation which the peripheral sensory fibres receive from the constant movement of air in the lungs and which is perhaps necessary to the respiratory reflex. The change that takes place in the play of the thorax after section of the vagi is not without analogy to the changes that are observed in open pneumothorax and we are tempted to see, in both conditions, the same explanation, viz.: the suppression of the centripetal impressions that are transmitted from the lungs to the medulla, only that in one case (section of vagi) this suppression of the respiratory movements is brought about by anesthesia of the lung, and

in the other (pneumothorax), by their immobilization and compression.

Several other theories have been advanced to explain the mechanism by which acute traumatic pneumothorax may lead to asphyxia, but Rodet and Pourrat's explanation appears to us as satisfactory, if not more so than other theories that have been suggested with less experimental or clinical evidence to support them. Another interesting point brought out by the researches of these observers in their studies is that the dangers of acute *open* pneumothorax are very much diminished by the repeated injection of small quantities of air into the pleura. By thus producing a partial and incomplete pneumothorax the lung and nervous centres are gradually prepared for the complete pneumothorax that is to follow. They determined that if air is forced into the pleura through a canula, in small quantities and at short intervals, relatively large injections of air are well borne. 100 c. c. in little dogs; 200-250 c. c. in animals of medium size; and 350 to 400 c. c. in large dogs could be repeated without serious disturbance. If a larger quantity of air (always sterile) is injected, a marked respiratory oppression is produced with a momentary weakening in the precordial impulse.*

*Since this was written, Dr. Murphy (*loc cit.*) has advanced a mechanical explanation for the asphyxia of pneumothorax, which has the merit of being original and ingenious if not altogether convincing. Dr. Murphy believes that "the dyspnea following opening of the pleural cavity is due to the vibration of the mediastinal septum and contents destroying the piston action of the diaphragm." After collapse of the lung had taken place, he observed while experimenting on a dog, that "the mediastinal septum and contents flopped to and fro in respiration like a sail during a lull; when the dog inhaled the mediastinal septum, concaved greatly to the uninjured side; when he exhaled it convexed to the opposite side. The chest ceased to be a cylinder for the piston—the diaphragm, in the respiratory act." * * * He found that by placing a forceps on the hilum of the collapsed lung and thus immobilizing the septum, he was able to relieve the dyspnea. It appears to us that, notwithstanding its debatable phases, this theory is, to say the least, very practical, and should be kept in mind for working purposes at the bedside and in the operating room.

In connection with Dr. Murphy's experiments in the production of artificial pneumothorax with nitrogen, it is curious to observe that Pourrat, in his thesis (1892), states that the sterilized air injected into the pleural cavity is absorbed in forty days, at farthest, and that on analysis it was found that oxygen disappeared much earlier than the nitrogen of the atmosphere. Rodet and Pourrat are also very careful in their description of the technic of the injection of air into the pleura, and describe a blunt canula with a lateral opening by which the pleural injections are very much simplified in their application. In this experimental work they had certainly anticipated some of Dr. Murphy's researches.

Lawson independently imbued with these ideas prepared his patient for the extirpation of a tuberculous apex by injecting sterilized air into the pleura as a preliminary to pneumectomy, thus preparing the lung and pleura for the free admission of air that followed the opening of the pleura, without evil effects, shortly after. In this way a *gradual* pneumothorax was substituted for an *acute* one. Witzel, the same year (*Centralblatt f. Chirurg.*, No. 24, 1890), and with the view of preventing the bad effects of sudden collapse of the lung in resecting the chest wall, injected sterilized water in sufficient quantity to fill up the pleura, substituting in this way a gradual hydrothorax for an acute pneumothorax.

The methods which have been tried successfully to counteract the disastrous effects of acute pneumothorax in the course of operations on the chest are the result rather of instinct and empirical experience than of a clear understanding of the physiological conditions that are at fault. The dominant idea, thus far, has been to act in such a way as to prevent further encroachment upon the crippled function of the lung, by the external air, than to *restore* the respiratory function by inflating the collapsed lung directly. From the days of Richerand, and long before him, in penetrating wounds of the chest, the first step taken by the operator was to immediately seal the opening; a practice which both in the clinic and in the laboratory has been productive of some, though not always, complete relief. The sealing of the external opening prevents further entrance of air and acts by diminishing the intra-thoracic tension, which would otherwise be intensified with every violent inspiration and paroxysm of cough. Sealing the external wound has been found to do good in all cases, but in many the relief experienced by this means is only partial: As in Doyen's case, in which final relief to the dyspnea was only obtained after the air contained in the pleura had been removed by aspiration. I could also quote one of my own experiences in which the patient was scarcely relieved. In other instances relief has been obtained by seizing the retreating lung and suturing it to the chest opening, which is sealed by it (Pean, Roux, Bayer *et als.*) Under

these circumstances the relief is doubtless obtained in two ways: first, by preventing the complete retreat of the lung upon its hilum; and, secondly, preventing further admission of air by plugging the opening in the pleura with the lung itself.

A great deal of time could be profitably invested in the consideration of this and other allied problems presented by the surgical pathology of the chest, but I have wandered far away from my original intention in writing this contribution, which is essentially to discuss the treatment of chest traumatism in the light of modern methods. I must therefore bring this chapter to a close by the following practical and almost axiomatic conclusions: (1) That whatever the essential causes of the phenomena of acute traumatic pneumothorax, they are always associated with the sudden, free, large opening of the pleura and immediate collapse of the lung; (2) that while these phenomena vary in intensity according to individuals and circumstances, and in some cases are so slight that they can be disregarded; (3) it is the duty of every surgeon, whenever he is about to undertake an operation on the chest or neighboring region which might involve the pleura, to assume that pneumothorax is inevitable and that he must be prepared to meet the evil effects of acute atelectasis.

XI.

It is evident that the most certain way of preventing the evil effects of atmospheric distention of the pleural cavity would be to obliterate it, at least in patches, so as to fasten the lung to the parietal pleura by adhesions, and thus prevent the retraction of the organ upon its hilum, when the pleura is opened. This is Nature's method, not only of preventing pneumothorax from pathological perforation of the bronchi, but also of circumscribing the influence of septic agencies from within. This suggestion, taken from nature, furnishes the key to the numerous experiments and methods for provoking adhesion by which the surgeons of the present period have endeavored to guard the entrance of the knife into the chest. The names of Quincke, Godlee, Bardeleben, De Cernville, Israel, Laache, Vautrin, Delageniere, Roux,

Walter, Quenu and Longuet are sufficient and prominent enough to prove that the efforts made in this direction have been numerous and determined.

The methods thus far adopted may be classified (Quenu and Longuet, contribution of December 1896) into: (1) methods that provoke adhesions by the application of irritants and caustics to the chest wall and pleura. This is simply a revival of Recamier's old plan of securing peritoneal adhesions over the liver, which we owe to Krimmer and Waller (1830) and latterly to Quinke, who has resorted to it with the same object, in the chest; (2) adhesions obtained by acupuncture, or by trocars allowed to remain *in situ* (Godlee, Bardeleben); (3) adhesions obtained by suturing the pleural surfaces as a preliminary to operations (Péan, De Cereville, Roux, Quenu, Laache, Godlee, suggested by Poulet, 1851,) or, secondarily, after the pleura has been opened in order to anchor the lung to the chest wall (Delagenière *et als.*). The secondary suturing of the cyst wall in operations upon cysts, hydatids of the lungs, etc., might also be referred to in this group (Israel, Poirier, Segond, Mannoury, Quenu, etc.).

Quenu and Longuet repeated in sixty experiments, all the methods recommended by previous observers, adding a good many original procedures of their own, such as the introduction of aseptic foreign bodies in the pleura, ignipuncture with the thermo-cautery, electrolysis, harpooning and transfixing the pleura and lung subcutaneously. As a result of their numerous investigations they came to the conclusion that it was impossible to obtain anything like firm or extensive adhesions without a certain amount of infection. That pleural adhesions, and in fact all inflammatory adhesions in serous membranes, are the result of some form of infection, no matter how much this may be attenuated. They believe that suturing the pleural surfaces, no matter how closely, or how much thread is used, will not cause the least exudation unless there is a certain degree of infection, which, in their carefully conducted experiments, averaged once in twelve cases. The success in securing adhesions which has been obtained by surgeons, the world

over, must therefore be due, if Quenu and Longuet are right, to a moderate amount of sepsis; an occurrence which is not surprising, as in the majority of cases in which efforts to obtain adhesions are most often made septic conditions exist, and contamination, in some form, takes place.

Notwithstanding their failure to obtain adhesions unless there was some infection of the threads, these investigators recommend a mode of pulmonary suture which they describe as "costopneumopexy," which is intended as a preliminary or first stage, to pleurotomy. By this method the lung is anchored to the ribs by passing a threaded needle (curved) through the interspaces close to the ribs, after all the tissues have been divided down to the intercostal muscles. The intercostal muscles, with a layer of lung tissue, are included with the parietal and visceral pleuræ in the grasp of the sutures, the ends of the thread being tied, or twisted, temporarily if wire is used, over the ribs. The advantages claimed for this procedure is that the sutures will hold very firmly by the intercostal muscles, which will not tear or leak as when the pleura alone is sutured. In cases in which there is no time to wait for adhesions to form, and it is desirable to circumscribe the pleura before opening a focus of infection, this method, or Roux' continuous back-stitch (*Arrière-point*) should be resorted to.

The advantages of adhesions are so obvious in pulmonary surgery that this point need not be further discussed. However, we have now come to a time when new expedients are being devised for preventing pulmonary collapse and for maintaining the functional activity of the lung after opening the pleura. It is these new expedients which promise most hopefully to revolutionize the surgery of the thorax in a manner that will relegate adhesions to a secondary and humbler plane.

XII.

The procedure that promises the most benefit in preventing pulmonary collapse in operations on the chest is the artificial inflation of the lung and the rythmical maintenance of

artificial respiration by a tube in the glottis directly connected with a bellows. Like other discoveries, it is not only elementary in its simplicity, but the fundamental ideas involved in this important suggestion have been lying idle before the eyes of the profession for years. It is curious that surgeons should have failed to apply for so long a time the suggestions of the physiological laboratory, where the bellows and tracheal tubes have been in constant use from the days of Magendie to the present, in practising artificial respiration on animals. It took the practical sense of an American physician, Dr. George E. Fell, of Buffalo, N. Y., to transfer the experience of the laboratory to that of the bedside. In 1893, he described at the Pan-American Congress (held in Washington, September 7, 1893), an apparatus that he had successfully employed for maintaining artificial respiration in cases of opium poisoning. His method is identical with that employed in laboratories to carry on respiration in animals by forcing air into the lungs through a canula inserted in the trachea, or by means of a mask applied over the mouth and nose. The danger of tracheotomy and the inefficacy of the mask, which were pointed out in the discussion that followed in Washington, were soon overcome by another American of inventive genius, Dr. O'Dwyer. The name of O'Dwyer will at once account for the radical transformation of Fell's apparatus in one essential, namely, the substitution of an intubation tube for a tracheotomy canula.

O'Dwyer's resurrection of Bouchut's crude ideas on intubation, and his magical transformation of the bloody and tragic picture of tracheotomy in diphtheria into a simple, painless and bloodless bit of technical jugglery by his perfected method of intubation, has practically closed for all time one of the most conspicuous chapters in the history of surgery. By similarly transforming the tracheotomy canula of the Fell apparatus to an intubation tube he unconsciously but fittingly opened to surgery a new chapter of greater interest and promise than that which his previous achievement had brought to a close.

Dr. O'Dwyer says, in commenting on the Fell apparatus: „ In the performance of artificial respiration, by any means,

it is important to remember that all we have to do is to get air into the lungs, and give it sufficient room and time to



Fig. 1.

THE FELL-O'DWYER APPARATUS.*

escape; the power generated and stored up in overcoming the resistance to inspiration being amply sufficient to carry on

* This illustration shows an early model; since then the bellows has been improved by the addition of a strong wooden frame which holds it steadily, and is provided with a long arm that acts as a powerful foot piece for compressing the machine, with the least amount of muscular effort.

expiration." Dr. O'Dwyer's substitute for the tracheal canula consisted in an intubation attachment with a laryngeal end curved on a right angle and tipped with a conical head, which is designed to be of the right size to wedge itself into the larynx and prevent air from returning between it and the laryngeal wall. The proximal end is practically bifurcated—one branch receiving the ingoing air from the bellows and tube; the other branch, stopped with the operator's thumb (which is to act as a valve), serves for the exit of the air. The value of this apparatus has been made apparent to English-speaking readers by the exertions of Dr. W. P. Northrup, who, describing it appropriately as the Fell-O'Dwyer apparatus, has demonstrated its inestimable value as the simplest and most effective appliance known for maintaining artificial respiration. He has represented the merits of this apparatus and the results of its application before the British Medical Association (Bristol meeting, 1894); Association of American Physicians (Washington meeting, June, 1895), and in the medical and surgical reports of the Presbyterian Hospital of New York for January, 1896.

In this last contribution he presents the reports of eight cases, which conclusively demonstrate the value of the apparatus from the purely medical point of view. We notice the following statements among his conclusions: (1) That the Fell-O'Dwyer apparatus is an efficient aid in carrying on prolonged artificial and forcible respiration. (2) The procedure is not necessarily attended with any injury of the larynx or lungs of the patient; (3) it requires but one attendant at a time and does not make unwarranted drafts upon the strength and endurance of such attendant; (4) the intubation tube can be inserted by the average physician without previous practice and to patients of all ages; the laryngeal end being easily adapted by its conical form to the dimension of any glottis. It is not only perfectly adapted to the larynx, but seals this so completely that even when the stomach contents are being washed out the tube in the larynx need not be disturbed. It has been kept in constant operation in some cases (opium narcosis, cerebral traumatism) for twenty-four hours

and longer (Northrup) without any injurious effect on the larynx, provided respiration is carried out at the rate of 12 to 16 times a minute, allowing plenty of time for expiration in order to accumulate air in the lungs. The apparatus has been used thus far most extensively in the treatment of acute opium poisoning, for which it is admirably adapted, and has already saved several lives in the practice of this Charity Hospital, where it was first introduced by the present house surgeon, Dr. J. D. Bloom. But, as already indicated, its range of application is as wide as the conditions in which respiratory failure from any cause is the dominant element of danger. As Dr. Northrup remarks, this apparatus commends itself as of great value in operations about the mouth, keeping blood from entering the larynx while providing an excellent normal respiration; also for cases of suspended respiration in ether and chloroform narcosis. An anesthetic may be administered through an intubation tube, or oxygen if required may be insufflated into the lung as a restorative agent.

We have demonstrated that the practice of artificial respiration *by intubation* of the larynx is an American invention, and that the excellence of the Fell-O'Dwyer apparatus as an appliance for the direct inflation of the lung, and for artificial respiration, had been fully established long before any foreign contrivances for the same purpose had been made. It is only just to note, however, that independent work has been done in this direction elsewhere, and that the *application* of a similar apparatus for preventing the collapse of the lung in penetrating operations on the chest and its contents is a suggestion that has come to us independently from the other side of the Atlantic. In a discussion at the Societe de Chirurgie in Paris (February 10, 1897), Delorme said that the need of an appliance to inflate the lungs had occurred to him when he first performed his operation of decortication and liberation of the imprisoned lung in chronic empyema. But the surprising manner in which the lung expanded spontaneously and filled the pleural cavity after it had been released from its confining shell of exudates, in his first case,

and, in another, operated by Lardy (of Constantinople), showed him that the expansion of the lung could be effected without the help of such an appliance and by the efforts of Nature alone. He believed that a sufficient increase in the intra-bronchial pressure is obtained by the closure of the glottis in the paroxysms of cough that occur in the course of the operation. But that Nature's unaided efforts are uncertain and can not be trusted under such circumstances is proven by other operators who have adopted Delorme's procedure. Cases of this class in which the lung is freed after a long period of inaction, and when ample opportunity has been given to the organism to accommodate itself to a crippled respiratory function are not apposite to the class of cases under discussion, as in these the desideratum is a certain means of preventing *acute pneumothorax* in surgical operations. Delorme also mentions a Belgian surgeon, Mr. Lambotte, as having advised some time before him, the artificial inflation of the lung in surgical conditions. But it is to Tuffier, Quenu, with their associates Hallion and Longuet, and to Doyen that we owe a debt of recognition for their scientific demonstration of the value of artificial inflation of the lung through the larynx for the prevention and relief of surgical pneumothorax. From what we can gather in the literature of this subject it would appear that the same thought had occurred to these surgeons independently of each other and at about the same time, and that they worked at the solution of this problem contemporaneously by different methods and expedients, all of which, however, tended to the same result.

Tuffier and Hallion reported their first experiments to the Société de Biologie, November 21, 1896, and Tuffier read a paper on the subject to the Société de Chirurgie in February, 1897. (Bull. et Mem. de la Société de Chirurgie, February and March, 1897). They were prompted to undertake their inquiry by their appreciation of the necessity of actively maintaining the functions of the lung in intra-thoracic operations. Their great merit is that they obtained this result by insufflating the lungs through an intra-laryngeal tube, and they secured the necessary data by which to regulate the intra-bronchial pressure with scientific

accuracy, though it is evident that Fell and O'Dwyer had resolved these questions in the simplest manner by mere clinical observations on the living subject. Tuffier and Hallion determined that an intra-bronchial pressure equal to 33 mm. mercury arrested respiration and defeated the purpose of the insufflation. A pressure of 6 mm. is all that is required to overcome the elasticity of the lung and equalize the air pressure. In addition to this, Tuffier and Hallion's experiments clearly demonstrate the great possibilities of pulmonary inflation in the future of intra-thoracic surgery. The following experiment will best illustrate their conclusions: "A dog was chloroformed, and a long copper tube attached to a bellows was introduced into the larynx through the mouth. Artificial respiration being thus established the pleura is incised freely, and the edges of the wound are kept wide apart to allow the air to enter freely. If the pleural cavity is then illuminated with an incandescent lamp, it is comparatively easy to perform operations on the esophagus, sympathetic and pneumogastric, without interfering with the respiration. Several dogs treated in this way recovered and survived several months without suffering any serious disturbance after the operation, and it is upon this point that we would especially insist to-day."

Coincidentally with Tuffier and Hallion's experiments with intubation, Quenu and Longuet undertook an extensive series of researches, chiefly with the object of determining the best means of securing pleural adhesions. Realizing all the difficulties which attended this process whenever it was attempted after collapse of the lung had taken place, they independently began to experiment with insufflation of the lungs with a cylinder of compressed air connected to a canula tied to the trachea. They also tried a simpler plan of making the animal breathe an atmosphere of compressed air by enclosing the head in an apparatus somewhat like a diver's suit. Notwithstanding all the imperfections of their methods they convinced themselves of the enormous advantages of any procedure that will compel the lung to remain in contact with the chest wall. They also observed the facility and safety with which the lung can be explored; and, in addition, the tendency to sponta-

neous hemostasis displayed by the lung when it becomes herniated in the parietal opening under these conditions. In conclusion they state their conviction that it is in this direction that further efforts must be made if the surgery of the chest is to make further progress.

It remained for Doyen's quick and inventive mind to complete the researches of Tuffier and Quenu. Whether independently of these investigators or profiting through their experience (he does not say in any of his publications), he devised a set of intubation tubes evidently suggested by O'Dwyer's models (which he does not mention however) and connected these with a bellows of his own construction, and thus completed an apparatus which reflects the greatest credit upon his mechanical ability. This apparatus was first described in his *Technique Chirurgicale*, pp. 129-33, and since then in a short article—*La Chirurgie du Poumon, Revue de Therapeutique Medico-Chirurgicale*, January 15, 1898, Vol. 65.

While Doyen's model is in several respects inferior for general use to the Fell-O'Dwyer apparatus, especially in the intubating part of the apparatus, it is nevertheless very ingenious in the construction of the bellows which can be used as an aspirator of gases in the pleura or for the purpose of administering anesthetics or oxygen by intubation.*

We may now allow the curtain to fall over the subject of acute pneumothorax as this is developed accidentally, or as the intentional result of the surgeon's operations on the chest for the relief of purely pathological conditions of its walls or contained organs.

* Since this contribution has been written, my colleague, Dr. F. W. Parham has brilliantly confirmed the opinion herein expressed as to the value of the Fell-O'Dwyer apparatus, by successfully removing a large sarcoma of the upper chest wall (involving the second, third and fourth ribs). The complete excision of a large quadri lateral area of the chest, including section of ribs, was necessitated by the invasion of the neoplasm. The pleura was opened freely, but the collapse of the lung which would have inevitably followed, and the bad symptoms that were beginning to be noticed, were immediately corrected by the Fell-O'Dwyer apparatus. This kept the lung freely distended and maintained a regular respiration until it had been sutured by continuous stitch to the parietal pleura and the wound had been closed, completely, by skin flap. The patient was taken to his ward in excellent condition, showing no serious shock. Some suppuration in the wound occurred but complete recovery has been confirmed and the patient is now about and well.

XIII.

A different question now claims our attention. How to deal with the penetrating (gunshot, punctured, stab) wounds of the chest, which are inflicted by accident or with purely destructive intent. What can the surgeon of the present do to improve upon the results obtained by his predecessors? Can we hope by the latest improvements in our technic to still further decrease the lowered mortality from this always dangerous class of injuries? What are the causes of the mortality? Hemorrhage, shock, pneumothorax and infection with its long train of secondary evils—pneumonia, pleurisy, abscess of lung, etc., are the factors—but hemorrhage, whether from the lungs, heart or the great mediastinal vessels, is the cause that kills the greatest number. Pneumothorax, which is the dread of the surgeon in his operations on the chest, sinks to a very secondary plane indeed in the history of the present class of injuries. In this respect the dangers of the penetrating wounds inflicted in war and in ordinary casualties differ radically from those we have referred to as “surgical traumatisms.” In the former, it is hemorrhage that chiefly imperils the life of the patient; in the latter, it is more often asphyxia, and why this difference?

That pneumothorax plays only a secondary part in history of penetrating chest injuries is clearly demonstrated by all the records of civil and military practice. Of course we do not know exactly to what extent simple asphyxia from pneumothorax may contribute to the mortality of those who are killed outright on the battle field or who linger in a moribund state for a few hours after they have been struck. But the examination of the dead on the battle field, which has been done carefully by a few observers (Löffler, Lidell, Mouatt), and the study of chest injuries in the wounded survivors, clearly indicate that pneumothorax has very little to do with the causation of such deaths. It is hemorrhage, always hemorrhage, from injury to the great vessels of the chest that accounts for the great mortality (*one-third, to one-half*) of those who die in battle.

The old maxim, “The gravity of a perforating wound of the

chest increases in proportion as its diameter exceeds that of the glottic opening," which has special reference to the dangers of pneumothorax, is as true to-day as when it was enunciated years ago by Hewson. It is the small size, long, tortuous and narrow tract of the wounds usually caused by firearms and ordinary weapons that accounts for the comparative insignificance of pneumothorax as a result of such injuries. Here and there a large opening is made by a knife, dirk or some other cutting weapon, but these wounds are comparatively rare by the side of the revolver or other gunshot injuries that we are called upon to attend in our hospital practice almost every day. In war, sword and bayonet wounds are becoming less and less frequent with each succeeding conflict; now, more than ever, is this true, since the long distance, small calibre rifle has been universally adopted by the armies of the world. But what is the largest stab wound, but a small and narrow opening when compared to the osteoplastic trap-door openings, veritable fenestra that admit the entire hand, which the surgeon is compelled to make to extirpate tumors of the chest walls or to facilitate intrathoracic manipulations? This is what really accounts for the difference in the importance of the pneumothorax as observed in these two conditions.

The pneumothorax that often follows ordinary wounds is only *partial*, *incomplete* and *gradual* in the vast majority of cases. Furthermore, we all know how often serious penetrating wounds involving the lung are free from the signs of pneumothorax, and this is easily accounted for when we consider how a bullet tract, especially that produced by the bullet of a revolver, can be obliterated by clotting of blood, by inflammatory edema, etc. Again, as pointed out by Koenig, a wound, though penetrating, may be immediately closed by a change in the position of the muscular layers through which it passes. The thicker the muscles the more likely is the channel to become oblique or valvular. If we also bear in mind the experiments on animals made by Dr. A. H. Smith, U. S. A., at the close of the Civil war to study the mechanism of pneumothorax, and West's later experiments

on the physics of the lung, in connection with pneumothorax, we can readily understand how even comparatively large wounds in the lungs or pleura will fail to overcome the natural "cohesive" force that keeps the two moist surfaces in close contact, as if glued together.

It is only in those rare cases in which (*a*) the external wound is oblique and valvular, and allows air to enter and none to escape, or when (*b*) the external wound is closed and the coexistent pulmonary perforation is valvular, that the pneumothorax which follows is likely to be dangerous. Under these circumstances, the intra-thoracic tension is progressively increased by the entrance of air into the pleura with each inspiration, and not only is the atelectasis complete but the uninjured side is dangerously encroached upon by the great pressure that is increasingly brought to bear on the mediastinum.

Then something must be done to relieve the dyspnea, which becomes intense. Under these circumstances, the oldest surgeons, Bell, Dupuytren, and Hewson, properly advised that the distended pleura be tapped with trocars or freely opened by incision, as in the operation for empyema. But the fear of atmospheric contamination, so much dreaded at that time, were opposed to this procedure. Malgaigne and others believe that free incisions only served to confirm the collapse of the lung. Nevertheless, Legouest, the surgeon of the Crimea, introduced a canula which he allowed to remain *in situ*. Bouveret, Orlebae, and many others reported good results from this practice. It is in these cases, in which the pneumothorax is associated with a valvular wound of the chest wall, that subcutaneous emphysema is likely to develop and assume its worst features. Usually, however, this complication is easily remedied by applying a firm antiseptic compress over the wound-tract over which the entire chest, more especially on the injured side, is covered with broad adhesive strips applied during expiration, thus immobilizing the chest. Others have advised plaster of Paris jackets to secure this immobility, but I have always found adhesive plaster reliable and satisfactory. In this way the

emphysema is effectively prevented from spreading. Before applying a dressing of this kind simple aspiration of the thorax may be tried to relieve the urgent respiratory symptoms, after which the immobilizing bandage is applied. Should this fail to relieve the dyspnea, Dupuytren's advice to enlarge the wound and convert it into a direct channel for the escape of the confined air would usually suffice to give relief. The lung itself could then be tested for perforation, provided there were no contra-indications, by inflating it with the Fell-O'Dwyer apparatus. If the perforation in the lung were large, or it communicated with a bronchus, it is not likely that the lung would expand, and the indication would then be to leave a drain in the pleura under careful and copious antiseptic dressings to provide for drainage, as the infection of the pleura through a large bronchus would be certain. If the perforation were small or tortuous, or the wound only implicated the pleura, the Fell-O'Dwyer apparatus would immediately relieve the pneumothorax by forcing the lung to the chest wall, where it could be safely anchored by deep sutures and the wound closed.

Witzel's suggestion to substitute a hydro-thorax with sterile normal solution, for the pneumothorax, is ingenious, but is not free from risks and inconveniences, in addition to its failure to meet the chief indication of the moment, which is to relieve the dyspneic symptoms. Gaillard, Pourat, Rodet and others have also sufficiently dwelt upon the fallacies of this procedure, which will not receive special attention in this paper, as the condition for which it is recommended is not only of rare occurrence but can be safely met by tapping, aspiration and the Fell-O'Dwyer apparatus, as previously indicated.

XIV.

We have reserved the greatest elements of danger, hemorrhage and shock, for final consideration. Shock, sometimes serious and fatal, may occur independently of hemorrhage. But its intensity, as a rule, is directly proportional to the blood loss. We shall therefore consider the treatment of these two conditions together. Hemorrhage may be classi-

fied anatomically according to its origin, but as it can only be clinically differentiated into parietal or visceral, including in this last cardiac and pulmonary hemorrhages, we shall adopt this as the basis of our discussion. It may be also primary or secondary, rapid or slow. The symptoms of internal hemorrhage, and the physical signs of a large effusion of blood into the pleura—hemothorax—or of the combined presence of blood and air, hemo-pneumothorax, may be detected almost immediately after the injury, and rapidly or gradually grow more marked until death closes the scene; or the signs may reach a certain height or intensity and then, under the influence of rest and sedatives, gradually subside, or stop spontaneously.

We have already referred incidentally to the great mortality of wounds of the chest, and to the fact that hemorrhage is its chief cause. It is now interesting to notice the causes that have favored its diminution, at least in war.

The mortality from these wounds has varied from 33 per cent. to 50 per cent. (Löffler and Lidell, etc.) of those killed in action. Löeffler in his summary of the statistics of the Prussian Army in the Danish campaign (1864) stated the immediate mortality to be 68 per cent. of the total wounded, of whom 44 per cent. died on the field of action, — 8 per cent. in the first 48 hours and 14 per cent. 48 hours after. In all these cases hemorrhage, as he ascertained, is the essential cause of death. The immediate gravity of these injuries of the chest is further confirmed when we consider that ever since the Napoleonic wars the proportion of chest wounds of all kinds to the wounds of all the other regions has fluctuated with slight variations from 8 to 11 per cent. of the total. When we consider the *total* mortality of chest wounds in war the matter assumes a more sombre aspect. De Santi, basing himself on Guthrie's figures, estimates the English mortality from this cause, at the battle of Toulouse (1814) at 87 per cent. In the revolution of July which stirred up Paris, in 1830, and led to much barricade fighting, the wounded being transferred immediately to the city hospitals, excellent opportunities were offered for the observation of the course of

these wounds, and their treatment, under the best hospital conditions and the highest medical skill of that period; and yet in the hands of Larrey, Baudens, Dupuyten, Joubert de Lamballe, Roux and Menière, the foremost surgeons of the period, the mortality was 77 per cent., showing conclusively that the advantage of immediate treatment had thus far failed to influence in any manner the previous mortality of this class of injuries. Under the evil influence of insanitary conditions the statistics were much worse in the Crimean war. There, a gunshot wound of the chest meant almost certain death. Thus the Russians at Sympheropol lost 197 out of 200 wounded, or 98 per cent.; the French, 88 per cent.; the English, 82 per cent.: total average, 89.7 per cent. (De Santi). Statistics improved in our Civil war. Out of 8715 penetrating cases, 62.5 per cent. died (Otis).

Very little improvement was observed in 1870, during the Franco-Prussian war. Sixty per cent. of the penetrating wounds of the chest in Werder's army ended fatally (Beck). At Metz, Fischer estimates the Prussian loss in wounds of this class at 50 per cent., though Billroth and Socin saw the mortality lowered to 28 per cent. in the station hospitals. This reduced mortality in the same war and in the same army simply confirms the observation made by Longmore and De Santi, that the reported mortality of these wounds, and in fact of visceral wounds in general, will vary according to the distance which separates the field hospitals from the scene of action, and the first line of relief, — the statistics improving progressively as the wounded survive the transportation to greater distances. The improvement is not due to better facilities or treatment in the division hospital, which is situated at a greater distance than the first relief stations or ambulances, but is mainly due to the fact that a number of those mortally wounded, or who are practically moribund, die before going further, and are eliminated from the statistics of the distant hospital. This fact, which is so thoroughly recognized by military surgeons, accounts not only for the different mortality in the hospitals under Billroth and Socin, as compared with the reater mortalities recorded by Fischer and Beck, but is equally

illustrated by many other notable examples in which the disproportion has been striking. The lack of parallelism between the statistics of Biefel, who lost 46 per cent. in the reserve hospital, while Stromeyer lost 66 per cent. in the relief hospital at the battles of Langensalza and Kirchheilingen in 1866; the statistics of Guyon at the hospital of Algiers, in 1854; of Ritter at Presburg, in the Bosnian war (1878), which would appear on the surface as showing extraordinary reductions in the mortality, simply show that the large, well organized central hospitals receive a better (more viable) class of patients than those who are first attended to on the battle field or in the intermediary stations en route to the large hospitals. Thus it is that the admirable results claimed by certain surgeons in the past are to a large extent illusions, and that all claims for superior results, when based upon greater skill in treatment, must be subjected to the most careful scrutiny.

This is particularly true when the figures are handled by enthusiasts in therapeutic methods, who are likely to take a one-sided view of statistics. A weakness of this character is evident in Gouzien's report of the results obtained by the French in the Tonquin and Formosa campaign of 1883-85, which would appear to show the unprecedented and extraordinarily low mortality of 10 per cent. for penetrating chest wounds, which the author attributes almost entirely to the superiority of the antiseptic treatment. But it is evident that these statistics take no account of the *immediate* mortality or that which occurred outside of the Station Hospitals. Had the deaths in the field or its vicinity been included in Gouzien's estimate the results would have shown at least 35 per cent. mortality, as Nimier, who compiled the statistics of the same campaign, states it was.

The study of military statistics from the historical point of view is as instructive as it is encouraging. The conclusions to be derived from this study as shown by De Santi and others is: (1) that the mortality of gunshot wounds of the chest has been steadily diminishing, from the beginning of the century to the present time; (2), that this improvement in the results has taken place in spite of the fact that the

relative frequency of these wounds has not changed, and rather increased; (3), that the number of perforating wounds has positively increased since the round ball has been changed into a conical missile and its penetrating capacity, due to the greater velocity and hardness of the projectile, has increased. This is the explanation of the fact that in the Crimean war only 20 per cent. of the chest wounds were perforating, while in the Franco-Prussian war 45 per cent. were of this character.

As De Santi again says, "the influence of treatment on the wounds themselves has had comparatively little if anything to do with the mortality until very recent times, as this was practically the same with insignificant variations from the commencement of the century until 1870. The general sanitary conditions which surround the sick amount of course to a great deal in determining the fate of the survivors, but these conditions counted for little in deciding the better results obtained until 1870.

It is to the constantly improving armament of nations with the new magazine rifle, its small bore and hard, small projectiles which penetrate everything, but leave clean-cut, smooth, and usually aseptic, tubular, tracts behind them, that we owe, more than to any special treatment, the greatly lessened mortality (at least 30 per cent. less than in the Crimea) of the wounded in recent wars.

The immediate mortality on the battle field will not be lessened; on the contrary, the number of those who perish in action will be increased, but the wounded survivors of the struggle will recover in greater number and much more promptly than ever before. The experience of the Chilians, of the Italians, in Abyssinia, of the Greeks and Turks, in their late war, of the English in the Chitral and other recent Asiatic campaigns, all confirm this impression and justify the belief that the present conflict of the United States with Spain will prove no exception. Undoubtedly the benefits of primary aseptic treatment have made themselves felt and have influenced in bringing about the better results that we have witnessed in recent conflicts; but to what extent primary aseptic

wound treatment in injuries of the chest, as elsewhere, is to be credited for the more favorable statistics is still an open question. The many factors, besides the *local* treatment of wounds, that have contributed largely and indisputably to better the fate of the wounded should never escape the notice of enthusiasts. That the better and far more successful treatment of the *septic post-traumatic complications* by modern methods have also contributed to reduce the mortality, no one can deny.

Gunshot wounds in civil practice have shown for a long time past decidedly more favorable tendencies as regards mortality from this cause.

Forgue and Réclus (*Therapeutique Chirurgicale*, 2d Edition, 1898) collected the statistics of various German and French hospitals and obtained the remarkably low figure of 12 per cent. as the death rate from penetrating wounds of the chest. In looking over the statistics of the Charity Hospital of New Orleans, from 1892 to 1896, I have been able to gather 245 wounds of the chest, almost all penetrating, treated in the indoor service, of which only 39 died, or 11.8 per cent. mortality, almost the same figures as obtained by Forgue in his study of the German and French hospitals.

This remarkably low mortality must be attributed, as Forgue and Reclus conclude, to several causes, among which the smallness of the projectile (these wounds being almost invariably inflicted with pocket revolvers); and, secondarily, the prompt relief given in the shape of rest and antiseptic treatment, including in this the avoidance of pernicious probing; sterilization of the wounded area and immediate sealing of the wound, etc.

XV.

Hemorrhages from the aorta and its large intrathoracic branches, the heart, the pulmonary arteries and veins before they penetrate the hilum, the *venæ cavæ* and *venæ azygos* are promptly fatal, especially if due to gunshot wounds. These are the chief causes of the great and unavoidable mortality from chest wound on the battle field. From the surgical or opera-

tive point of view they need not be considered, as the patients die, as a rule, before they can be reached; though, to this rule the records show some remarkable exceptions.*

It is more than probable, as shown by recent reports, that more frequent and successful attempts will be made in the future to relieve the stab and punctured wounds of the heart that survive the immediate effects of the injury; but this class of cases will ever be rare, in spite of the brilliant example of Farina, Capellan, Rhen, Parozanni and Parlavecchio. As to the *gunshot* perforations of the heart, they will continue, for obvious reasons, to spare the surgeon even the contemplation of his helplessness to relieve them.

XVI.

The dangerous hemorrhages of the chest that more frequently give the surgeon an opportunity for the application of direct hemostasis are those resulting from parietal, pulmonary and diaphragmatic wounds.

In spite of the antiquity of the recommendation, I would insist upon the importance of carefully examining all wounds of the chest, presenting serious symptoms, for injury to the internal mammary or intercostal vessels.

The fact that bleeding from these vessels is frequently overlooked because it is so often concealed and internal has been clearly impressed upon my mind by two cases of stab wounds of the internal mammary artery and one of the intercostals that have come under my observation. All of these cases occurred in the Charity Hospital; the two mammary injuries ending fatally. In one of these, at least, a careful and thorough examination would have probably averted the fatal end.

* Otis and Delorme, among the military surgeons, have collected a number of wonderful cases of survival after injury of the large arterial and venous trunks in addition to the more numerous recoveries after heart injuries. A rough idea of the proportion of the fatalities from hemorrhages due to injuries to the great vessels as compared with the lung injuries is obtained in a statement made by Liddell. At New Berne he examined thirty-two dead from chest wounds, and of these, at least eight had wounds which must have involved the heart and great vessels. (Otis' Surgical History of the War of the Rebellion Vol. II.

STAB WOUND OF THE INTERNAL MAMMARY ARTERY PENETRATING INTO THE PLEURA AND PERICARDIUM AND COMPLICATED WITH AN ENORMOUS HEMOTHORAX; SYNCOPAL SYMPTOMS AND COLLAPSE PRECEDED BY GREAT DYSPNEA. SALINE INFUSION WITHOUT RECOGNITION OF THE CAUSE OF HEMORRHAGE; MARKED TEMPORARY BENEFIT, DEATH.*

A. B., male, negro, æt. twenty-five years: was brought in the ambulance suffering from the effects of a stab wound of the chest, implicating some large vessel. Much external hemorrhage had taken place at the time of the injury, but this was stopped without much difficulty. When brought to the hospital, the patient was very pale and suffering from profound shock, breathing short, rapid; pulse intermittent, very rapid and almost imperceptible. Consciousness retained. Complains of a feeling of great oppression in the chest. Messrs. A. and M., the ambulance surgeons, immediately injected an extemporized saline solution in the median cephalic. The pulse improved at first as the fluid flowed into the veins, and almost the normal rhythm and number of beats had been reached when the injection was stopped. About two pints were injected. Though the pulse was very notably improved, the respiration still continued quite rapid and panting. The general effect on the patient was most remarkable. He appeared greatly relieved of his previous anxiety and distress and so expressed himself. The effects of the injection were temporary, however, and the patient succumbed about four and one-half hours after admission.

The *post-mortem* examination revealed an enormous hemothorax, caused by a completely divided internal mammary artery (third interspace). The pericardium had also been perforated, but the heart was intact. In this case vascular depletion, anemia and apnea, from complete compression of the left lung, were the causes of death. Still, in spite of these eminently lethal conditions, life was prolonged several hours by the saline infusion. It is reasonable to conclude that this patient would have recovered had the original wound been enlarged and the bleeding vessel secured *in situ* while the patient was being stimulated with the hot saline solution. The belief that a large pulmonary vessel or the heart had been injured discouraged any attempt in this direction.

We will now report another case in which the injury was precisely similar, and yet, in which, notwithstanding the ligation of the divided mammary and exploration of the heart and chest while the infusion was being applied, the patient died in less than twelve hours after the intervention from the combined effects of traumatic anemia and apnea.

* Abstracted from the author's paper entitled "A Clinical Report on Intravenous Saline Infusion in the Wards of the Charity Hospital from 1888-1891." Louisiana State Medical Society's Transactions, 1891, and New Orleans Medical and Surgical Journal, July, 1891. p. 16.

PENETRATING STAB WOUND OF CHEST, INVOLVING INTERNAL MAMMARY ARTERY, PERICARDIUM AND HEART (WITHOUT PERFORATIONS OF HEART); LIGATION OF WOUNDED VESSEL; HEMOPERICARDIUM AND HEMOTHORAX; REPEATED SALINE INFUSION; EXPLORATORY THORACOTOMY; DEATH FROM SHOCK, HEMORRHAGE AND EXHAUSTION.*

F. White, male, æt. 25 years, laborer, at 2 A. M., April 6, 1897, was stabbed by a companion in a drunken brawl. The wound was inflicted with a pointed clasp knife, which entered one-third of an inch to the left of the second sterno-costal junction, on left side. The wound was a little over one-half an inch in breadth, and was directed obliquely downward and to the left. The cartilage of the second rib was almost completely divided and part of the interspace below was involved. When seen by the ambulance surgeons the patient was completely collapsed, and it was believed that he would scarcely survive the transfer to the hospital. He had bled profusely from the external wound, but this had finally stopped spontaneously by the formation of a clot. While in the ambulance the clot became detached and the bleeding was renewed. Upon arrival at the hospital the assistant house surgeon on duty made a careful examination and decided that the internal mammary artery had been injured. The pulse was so weak that the patient was at once infused, and received three-quarters of a gallon of hot saline solution, intravenously, with decided restorative effect. The man's condition was so serious, however, that it was decided to disturb him as little as possible. Instead of a regular dissection and ligation of the injured vessel a deep wire suture was passed through the thickness of the chest wall, encircling the wounded vessel in the interspace, the ends of the wire being firmly twisted over an iodoform gauze roll, which with two other stitches completely closed the comparatively small wound.

The bleeding appeared to be controlled by this means and the patient was put to bed, where he was warmed up with hot cans, etc. The great shock and signs of internal hemorrhage aroused the suspicion that in addition to the internal mammary, the heart or lung had been injured. The length of the blade, the great violence of the blow which had nearly cut the cartilage in two, and its position in the præcordia, confirmed this impression. Under the usual treatment, rest, morphia hypodermically, strychnia, etc., the patient gradually improved during the night: the pulse grew strong and the respirations moderated in frequency. Early in the morning (April 7) notwithstanding his extreme pallor, hope was entertained of his recovery. Later in the morning, after 9 A. M., and after taking liquid nourishment, a change occurred, the patient complained of distress about the heart, the face grew more anxious, the respirations became more violent and the pulse weaker. I saw the man about 11 A. M. and was at once struck with the gravity of his condition. He was gasping for breath, his face was livid, almost cadaveric in hue: cold sweat bathed his forehead, and his pulse, 150-160, was almost imperceptible at the wrist. I renewed the dressings and noticed a marked fullness in the præcordia, and inter-

*I am largely indebted for the notes of this case to Dr. A. E. Hagen, of New Orleans, who embodied it in his excellent graduation thesis (unpublished): Reports of five gunshot and stab wounds in and about the pericardium. Medical department Tulane University; class 1896-97. Dr. Hagen was in attendance as interne in my service, Charity Hospital, ward 9, when this patient was admitted.

costal spaces on the left side and great tension in the wound as if it were about to tear open. There was complete flatness on percussion over the entire left thorax. Evidently the man was dying from hemorrhage into the pericardium and pleura. In spite of his desperate and unpromising condition I decided to make an effort to reach the bleeding point. I was ably assisted by the late Dr. J. Leake, who took charge of the intravenous saline infusion, which I decided to repeat once more before attempting any operative treatment. A canula was introduced into the right median cephalic and after a part of the decinormal saline solution had flown in, the pulse began to improve. The line of incision was mapped out with an infiltration of 1 per cent. cocain solution, and a cone containing a little ether was held over the patient's nose, but no attempt was made to secure general narcosis. The wound sutures were then cut and a gush of dark blood and clots followed as the wound burst open, showing that the blood had accumulated under great pressure in the mediastinum or pericardium. As the original wound was insufficient to expose the mammary artery, and believing that this great hemorrhage came from the pericardium or the heart itself, I freely enlarged the opening by an incision on a level with the second cartilage, horizontally, and for over four inches to the left; a vertical incision, at each end of the horizontal cut, completing a figure H, which permitted two osteoplastic flaps to be reflected upward and downward. The second and third cartilages with part of the corresponding ribs were rapidly cut with a costotome, and the two osteoplastic flaps, consisting of cartilage, skin and soft parts, were easily separated, and the mediastinum freely opened to the fourth rib. The internal mammary was then seen completely divided in the second interspace, close to the cartilage, where it was still spurting, and evidently the chief cause of the hemorrhage. It was also evident that the perivascular silver ligature, which had been applied on admission, had entirely missed the vessel, and failed to accomplish its purpose. This again shows the necessity in all similar cases not to trust to ligatures *en mass*, but to follow the golden rule, and to cut directly to the bleeding vessel, and secure it at the bleeding point. The vessel was seized with forceps and ligated on the proximal side. By the double trap door opening that had been made in the precordia, the mediastinum and pericardium and pleura had been freely exposed. The chest appeared to be filled with blood, every inspiration causing it to well up almost to the surface of the skin. After removing the clots and blood by sponging and irrigation with neutral saline solution I failed to discover any bleeding point. The heart was plainly exposed before us, and its tumultuous, irregular and churning movements as they lashed the serum and blood into a foam made a deep impression on all present. The constant motion of the air as it rushed in and out of the large fenestrum in the chest, combined with the violent efforts made by the patient to breathe, added to the tragic character of the occasion. The impression produced on all present was that the pericardium had been freely opened and that the blood that we saw was contained in its cavity. The post-mortem examination subsequently proved, however, that the pericardium had been wounded to the extent of one inch only and that the bleeding had been mainly extra-pericardial, mediastinal and intra-pleural. The pericardial cavity was really free from blood and the membrane had adjusted itself so accurately to the surface of the heart that the organ was seen through it as if wrapped in a transparent veil. We all examined carefully and failed to see any wound of the heart itself. In fact no other bleeding point could be detected outside of the original mammary injury which we had controlled. All the bad symptoms

were therefore due to hemothorax, collapse of the lung and shock. The lung was so completely collapsed that I could scarcely see it behind the heart. The condition of the patient in the meantime was most alarming and distressing to behold. The pulse had been reduced from 160-170 to 120 by the saline infusion, of which nearly 3 pints had been injected, intermittently, and the volume was a great deal better, but the respiration was very bad. The lips were livid, bluish-black, and the whole picture was that of intense respiratory distress. After freely irrigating, flushing and filling the pleura and pericardium by pouring pitchers of hot saline solution, a procedure which I thought might, on account of the heat, have some restorative effect, as it sometimes has in the peritoneum,—but which in this instance failed totally to produce any marked effect.—I hastened to close the wound and put on an occlusive and aseptic dressing.

I believe now that if I had only been able to inflate the collapsed lung and had sutured it to the chest wound, that the man's condition would have improved, and he, perhaps, saved. But we knew nothing of the Fell-O'Dwyer apparatus at that time. The entire closure of the wound was quickly terminated, and in fact the whole exploratory procedure, including the ligation of the mammary artery, involved a comparatively short time (not over 25 minutes). The pain involved in making the osteoplastic flaps appeared to be greatly obtunded by the partial asphyxia that existed; at least the patient made little, if any, complaint, though he was perfectly conscious throughout. The skin flaps were sutured with interrupted stitches, but two drainage tubes were left at the lower angles to favor the escape of bloody serum. After this a heavy gauze and cotton dressing, over which a large flat plate was applied to compress the wounded area more thoroughly and seal it hermetically. Adhesive strips and bandage further secured the entire dressing and chest. The patient was then stimulated freely with strychnia, digitalis, whisky and aromatic spirits of ammonia in the endeavor to relieve the dyspnea and great exhaustion. The pulse was never reduced lower than 115 at its best moment. It continued fair as to fullness and frequency shortly after the infusion was discontinued, but it was extremely irregular. The cyanosis became more and more marked after the operation. Respirations more shallow and hurried. A cold, clammy perspiration bathed the surface. By night-time it failed and the patient sank apparently from complete exhaustion, due to shock, hemorrhage and asphyxia. The autopsy, held the same night, revealed a large amount of bloody fluid (serum and saline solution) in the pleural cavity. The pericardium showed a wound not much over half an inch in length. The left ventricular wall was punctured about $1\frac{1}{2}$ inches above the apex, and about $1\frac{1}{2}$ inches to the left of the anterior interventricular groove. The puncture was very small, barely $\frac{1}{4}$ inch deep, and did not penetrate into any of the heart cavities. The pericardium contained 4-5 ounces of sero-sanguinolent fluid, but no clots.

Clearly, the primary cause of death was the wound in the mammary artery.

The intercostals have also furnished me with at least one instructive experience:

A negro, age 40, was struck a sharp blow with an axe the upper edge and point of which entered the chest on a level with the ninth rib, about a hand's breadth from the lower angle of the scapula and to the outer side of it. The rib was cut in two, and the pleura punctured. The man became very weak and faint and bled very freely

from the wound, which was about three inches long. A local physician washed the wound carefully, closed it with deep sutures and put on a firm antiseptic dressing. The man grew worse, however, and was sent during the night to the hospital. The next morning I saw him in Ward No. 2, and finding him very pale with very rapid and scarcely perceptible pulse, and in great distress with his breathing, I concluded that serious hemorrhage was going on in the pleura. The dressings were removed and the great tension of the wound and intercostal spaces confirmed my impression. The patient was at once prepared for operation and stimulated with brandy, digitalis and strychnine. No anesthetic was given. The sutures were cut, the wound was reopened, and some escape of blood followed. The axe had cut the rib completely and with it the intercostal artery and vein at a distance of about ten inches from its origin. The vessel could not be seen or secured with the ligature until nearly two inches of rib had been removed with the costotome. In order to do this a syringe full of cocaine solution, 1 per cent., was injected in the neighborhood of the nerve on the proximal side. Whether it was due to this or to the man's own fortitude, he made little complaint. After securing the vessel the pleural opening was enlarged and a considerable quantity of fluid blood and clots (nearly two quarts in all) escaped from the pleura. The pleura was immediately closed to prevent pneumothorax. The patient became very faint by this time: his pulse nearly imperceptible. We hurriedly sutured the wound and applied a firm dressing. In the meantime, the ordinary stimulants were applied freely, whilst he was warmed with hot cans: the head was kept very low. After a long suspense the patient rallied. He did well for the next four or five days, when signs of pleural infection showed themselves, which necessitated the introduction of a drain in the pleura. The patient was so exhausted that for a long time we did not believe he would live: finally, however, he recovered.

Cases of this sort readily explain the bad results that have been so frequently recorded as following injuries of intercostal arteries. "In the civil war, out of a total of 15 cases variously treated, 11 ended in death. In 8 an operation was performed; of these 6 died; one from pyemia, 1 from empyema, 1 from exhaustion, and 3 from secondary hemorrhage. The operations had scarcely been more successful than the cases treated by compression. But because this was the case are we justified in believing that it is not necessary to operate in these cases, or to do more than plug the wound?" (Paget.) These experiences simply show the need for more thorough and prompt investigation of all deep wounds which are situated in the anatomical course of these vessels, especially where they are of larger calibre, as in the posterior half of the thorax, nearer their origin. In conditions of great exhaustion, and where there is doubt that bleeding is actually going on, it may be sufficient to plug the wound with a Desault's

bag or tampon, which can be aptly compared to a small Miculickz' bag, thoroughly packed so as to compress the wounded vessel. But, when the situation does not improve and there is evidence that bleeding is going on, the quickest and surest treatment is to enlarge the wound (in extreme exhaustion, with cocain anesthesia as a help), and expose the intercostal or internal mammary. With the help of the Rongeur or a sharp costotome this work can be done quickly. The subperiosteal resection of a rib is so certain to expose the bleeding vessel, and is so easily accomplished, that there is no excuse for delay in critical conditions when the patient's life hangs in the balance.

XVII.

But if the intercostal or internal mammary arteries are not at fault, must we stop after ascertaining positively that the hemorrhage is internal? This brings us to the question: Whence does the hemorrhage come if it is not from the parietes? We have already noticed that bleeding from a wounded heart, aorta or the great arterial and venous trunks of the mediastinum will kill so quickly through the fierce bleeding that follows that we rarely see these patients outside of the moribund condition.

The bleeding wounds of the lung which give rise to progressive hemothorax are those that offer some hope for the direct ministrations of surgery, notwithstanding the gloomy prognostications of many eminent surgeons. The source of the bleeding in the lung is a question that did not appear to interest the older surgeons even down to the time of Larrey. All that they cared to know was whether the hemorrhage was parietal or visceral. If it was decided that the bleeding was visceral, that was the end of the inquiry. Nature and the materia medica could alone come to the rescue, except when occasionally, the surgeons would enlarge the wound to allow the pent-up blood to escape. Dupuytren, in his clinics, was among the first to discuss the source of the blood in hemothorax. He believed that an abundant hemorrhage into the pleura could only occur as the result of injury to the large vessels

at the root of the lung. In 1853, Jobert de Lamballe ascertained by actual cadaveric examination that superficial wounds of the lung only give rise to insignificant hemorrhage, and that the parenchyma bleeds but little when wounded. Dupuytren's teaching was generally accepted until about 1880, when Charles Nelaton's experimental, clinical and anatomical researches came to light and proved three things: 1. That wounds of the large vessels (arteries and veins) at the root of the lung, before they subdivide in the substance of the organ, are invariably fatal in from 9 to 10 minutes. In the animals experimented upon, a wound of these vessels caused the blood to spurt in a large stream which quickly filled the pleura and compressed the lung. The animals expired in the midst of intense dyspnea and anxiety. It is possible that the coincidence of acute pneumothorax had something to do with these bad results, but the profuse hemorrhage observed by Nelaton is quite sufficient to convince us that wounds of this class are almost as promptly fatal as those of the aorta or vena cava. What are the wounds, then, that give rise to the hemorrhages which, though very serious, will allow of sufficient survival to permit of surgical interference? According to Nelaton's investigations they are the arterial branches of the second and third magnitude which accompany the larger divisions of the bronchial tubes. These vessels are not only of large size, but have a tendency to bleed freely, even when the lung is collapsed or compressed by the extravasated blood. The cartilaginous resistance of the larger bronchi to compression and the close connection of these vessels with the open tubes prevents the retraction of the arteries even after complete collapse of the lung has taken place. Therefore, the most dangerous zone of hemorrhage is a comparatively circumscribed area in the neighborhood of the hilum; the zone rapidly diminishing in importance as the bronchi become smaller and lose their cartilaginous resistance. The fact that this hemorrhagic area is comparatively small as compared with the mass of the lung accounts for the frequency of recoveries after complete perforating wounds of the chest, and also for the comparative rarity of that middle class in which the primary hemorrhage

is not so furious as to cause immediate death and yet bad enough to resist nature's hemostatic resources and thus bring about a fatal termination at a later moment. The surgeon can not, of course, be expected to determine the primary seat of the hemorrhage. He can usually diagnosticate a lesion of the lung and judge of the importance of the vessel injured by the rapidity and extent of the hemothorax and also by the symptoms. He can not localize the lesion with precision, but he can tell if the patient is bleeding to death. It is in this last class of cases that we are now interested, as it would be superfluous to consider those in which the symptoms are of moderate intensity, and in which the usual classical rules of treatment yield perfectly satisfactory results.

XVIII.

What, then, is the best course to follow when we clearly determine that the bleeding is profuse and does not come from the chest-wall? Shall we pursue a conservative policy to the last, trusting that something favorable will turn up, or shall we resolutely proceed to investigate and treat the bleeding point by free exposure of the wounded lung or other bleeding surface? This question has been frequently asked in medical assemblies, and has been answered at various times in different ways, in accordance with the resources of the period. In fact, the history of the perforating injuries of the chest, like those of the abdomen and cranium, is a faithful reflex or mirror of the history and progress of surgery in general. At the present moment this question has not yet been decisively or, at least, unanimously answered by those most competent to express an opinion. Unfortunately precedents and statistics are insufficient to decide on the question of intervention or non-intervention, of expectation or aggression, in this matter, and the course of the practitioner must largely depend upon his individual judgment, skill and experience.

That a tendency to aggressive action is developing rapidly in the most advanced centres of surgical teaching is unquestionable, especially since the great discussion started by

Reclus, at the French Surgical Congress in 1895, aroused new interest in this direction. Nevertheless, the attitude of the most authorized teachers of surgery here as in England, is decidedly conservative in tone, a conservatism which, in purely educational texts, is evidently proper at a time when the tribunal of authority is still waiting for more evidence before rendering its final judgment. Thus we find the authors of American text-book of surgery (edition 1897) expressing themselves as follows: "The day may come when thorax will be opened for access to the wounded lung, pericardium, and heart; and the experimental results of Bloch and others, on the lower animals would warrant this belief, but the time has not yet arrived when the general recommendation of this course is justifiable." All the older texts are still more formal in the injunction not to interfere. They tell us if the hemorrhage comes from the lung, simply close the external wound, place the patient on the injured side and apply ice bags to the chest. Give morphia, ergotin, hypodermically; turpentine, aromatic sulphuric acid, gallic acid, etc. If the bleeding continues and it is evident that great distention of the pleura exists we are advised, and, (in fact, there has been no other alternative hitherto), to reopen the wound, and if necessary enlarge it for the removal of the clots. Ice cold water injected into the pleural cavity has been recommended by Delorme; but if the bleeding continues, the wound must be again closed, cold applied externally and the patient laid upon the wounded side, "thus persevering," as Otis remarks "opening and closing the wounded side, hoping to gain time and stave off the most pressing danger." (Stevenson, Wounds in War, 1898, p. 309.) This uncertain state of opinion is a repetition of the history of perforating wounds of the abdomen when in bleeding cases "to operate or not to operate" was the anxious question. In the abdomen, that question has there been definitely decided, and "*to operate*" is now the command whenever there is just enough life in the patient to sustain the traumatism required to arrest the hemorrhage.

In contrast with the policy of expectation, which trusts solely to Nature's efforts, we hear the voice of many men of

recognized judgment and discretion who believe that Gluck's dictum: "*Ubi hemorrhagia, ibi ligatura*," as applied to chest wounds, is as sound in precept as in dealing with hemorrhage in more accessible parts of the body, provided it is carefully tempered with a due amount of discretion. The matter was clearly presented by Reclus, in 1895, when, quoting the unfortunate but remarkable cases of Omboni and Delorme, he asks: "Shall we be discouraged that they failed? I think not. I believe that in a case of hemorrhage persisting in spite of rest, immobilization of the chest wall and occlusion of the wound; if the loss of blood is endangering the patient's life, is filling the pleura and threatening to stop the action of the heart, or of the lung, then a free opening into the chest will enable the surgeon to stop the bleeding by tying the vessel, or the piece of lung which is wounded, or by packing the wound with iodoform gauze. If we wait, the patient may bleed past hope of help; on the other hand, we must not forget that it is a very serious business to interfere in these cases, to inflict the shock of operation on a patient already enfeebled, and to induce pneumothorax of the whole side of the chest, over and above the disadvantages which are already hindering the vital changes in the blood."

Michaux, who reported a successful case of gunshot wound of the lung in which the bleeding was arrested by direct pressure with a gauze pack, quotes Charles Nelaton's thesis of 1880 (on hemothorax) in support of operative interference. Nelaton's statistics show that the mortality of the great hemorrhagic effusions caused by wounds of the lung embrace at least 50 per cent. of the cases when treated by expectation and ordinary methods of treatment. This fact alone, Michaux believes, justifies the intervention of surgery, though he recognizes that many of these deaths were due to secondary septic causes. The surgical indications should not be based upon a single symptom. Michaux mentions the following conditions among the positive indications for operation: (1) Indubitable symptoms of a recent extravasation, extensive flatness on percussion, absence of vocal fremitus, etc. (2) More or less dangerous topography of the wound (neighbor-

hood of the heart, of the intercostal and mammary arteries). (3) Exhaustion, anguish, dyspnea, if progressively increasing. As long as the danger is not pressing and there is doubt as to whether the hemorrhage is increasing, it is much better to wait a few hours if necessary in order to observe the conditions carefully and not act unnecessarily. The great indication for action is positive evidence of *serious and progressive* hemorrhage.

Under these circumstances the secret of success lies in the judgment of the practitioner who knows *when* to act and not wait until the opportunity has passed. Once the conviction comes that the patient is bleeding to death, prompt and decisive action is called for without losing time in abstract possibilities of spontaneous recovery. Réclus, Délorme, Michaux, Berger, Terrier, Souligoux, and finally Stephen Paget, whose well balanced judgment and profound knowledge of the problems involved no one will question, agree with many others that this is the proper course to pursue.

But it is plain that we should never undertake the exposure of the injured or bleeding lung without thoroughly weighing the patient's capacity of resistance to shock or further traumatism, and without due preparation for the serious contingencies that will certainly arise in the course of the operation. The conditions that are to be most feared under these circumstances are, fatal shock and uncontrollable hemorrhage, cardiac and respiratory failure; and it is fortunate that in dealing with these perils the contemporary surgeon is armed with better resources than were ever accorded to his predecessors. So recent, in fact, are these acquisitions that I scarcely believe that it is justifiable to even estimate the possibilities of thoracic surgery in dealing with visceral, and especially pulmonary, traumatisms until the restorative influence of intravenous hot saline infusion, given as a prophylactic against shock and as a preparatory measure in preventing it, as well as in relieving the exhaustion and vascular depletion [not as it is usually resorted to *after* the shock of additional traumatism has finished with the little vitality that is left in this class of patients] has been thoroughly tried. In

addition, the possibilities of artificial respiration with the Fell-O'Dwyer apparatus to prevent asphyxia from pneumothorax should never be forgotten in estimating the future prospects of this class of patients.

XIX.

In preparing to operate upon patients in such critical conditions as those herein contemplated, the proper procedure is to begin by exposing a vein in the arm or leg and introducing a canula through which the saline solution can be infused steadily before the anesthesia is begun. In the majority of these cases the condition of the pulse is so bad and the cyanosis so great that neither chloroform, ether, or the Schleich mixtures are well borne. The fear of these anesthetics led me on one occasion to use cocain in very weak strength, $\frac{1}{5}$, and $\frac{1}{10}$ per cent. (Schleich formula), with sufficient effect to permit me to make an osteoplastic flap including four and one-half inches of a rib with comparatively little pain, the intercostal nerve having been thoroughly anesthetized on the proximal side with cocain before the rib section was made. At other times in which the administration of a general anesthetic was absolutely required, the general condition improved so much after the saline infusion had begun that I was able to administer chloroform in minute but sufficient quantities to produce the necessary anesthesia. On the other hand, if, under the influence of the infusion, the pulse fails to improve, it is perfectly useless to continue and all hope of operative relief must be abandoned, unless the cardiac failure is attributable to respiratory embarrassment from collapse of the lung, when inflation of the lung and artificial respiration with the Fell-O'Dwyer apparatus should be tried in conjunction with the saline infusion.*

If under these conditions the pulse progressively improves, then the operation should be continued and pushed to a finish

* For technic and other details, see author's report on "Intravenous Saline Infusion," in the wards of the Charity Hospital of New Orleans from June, 1888, to June, 1891. New Orleans Medical and Surgical Journal, July and August, 1891.

as quickly as possible. While the saline infusion is flowing, the assistants should sustain its action by hypodermic injections of strychnin, caffenin, camphor, digitalin, ether or dilute ammonia. Enemas of brandy and champagne with hot coffee will also be found serviceable. The saline infusion should be kept up as long as the pulse is not a safe one. When reasonable conditions of fullness and slowness have been reached, the infusion can be temporarily suspended, leaving the canula in the vein, the infusion to be renewed again if the condition of the circulation calls for it. The solution should be *hot*, not lukewarm, as hot as the hand can comfortably bear it, and the quantity to be administered should be measured solely by the effect on the patient and not by any fixed standard of measurement.

Saline infusion is a remedy that I have learned to trust as an anchor of salvation in almost all great surgical crises in which the heart is flagging and is about to surrender. It is an agent to be relied upon when all other remedies in the *materia medica* fail. I have seen it bring the pulse back when the picture of death was almost complete and dissolution appeared to be inevitable. Under its magic influence the heart muscle is roused to renewed effort, the stagnant oxygen-carrying corpuscles are again set in motion and the tide of life is restored. Of course, saline infusion has its limitations, but it is in bridging over a crisis when death from shock and hemorrhagic depletion threaten to jeopardize the success of a final heroic effort that it is of priceless value. In the last few years I have performed many operations which I would not have dared undertake and in which, I know, the patients would not have survived the operative act itself, without the vivifying, almost resurrecting, influence of this remedy.

We have already noted the comparative helplessness of the surgeon in dealing with the collapse of the lung in other conditions in which the pleura is opened and the failure of the expedients that are usually recommended for this purpose to meet the urgent indication of the moment, namely: to restore immediately the aerating function of the injured lung. Artificial respiration by any of the recognized procedures, Syl-

vester's, Marshall Hall's, Howard's, etc., is an absolute failure when practised on a subject whose pleura is wide open. Simple closure of the chest wound, pulling the collapsed lung with forceps and tacking it to the wound, filling the pleura with warm sterile water, etc—all these have more or less served their purpose in preventing further collapse of the lung by the admission of air, but they fail totally in restoring its respiratory function at the time when this is most needed. It is in this respect that the Fell-O'Dwyer apparatus, or other appliances (Doyen's) that act on the same principle, are destined to revolutionize all past experience. With it, not only pure air but oxygen is insufflated into the lung, intra-pulmonary tension is restored, atelectasis is overcome and a regular rythmical respiration is maintained. It may be objected that a return of the normal, increased intra-pulmonary tension in a collapsed lung will favor the return of hemorrhage by the displacement of clots or increase in the vascular tension; against this objection it may be said that the greater access of the lung that is obtained by inflation will favor the certain and ready obliteration of the bleeding surfaces by suture. Wounds on the inner surface of the lung can be brought to view by lifting the anterior edge of the lung and drawing it out of the wound. Some of these wounds will perhaps be controlled by the thermo-cautery, but in a general way suture of the wound, followed by anchoring of the lung to the chest wall, by the procedure previously referred to as costo-pneumopexy (Quenu) will be the simplest and most often available method. It may also be objected that if there is a decided tear in the lung, with or without involving a bronchus, it will be impossible to inflate it. This is very true, but the objection is partially overcome if the wound is sutured carefully while the lung is collapsed; in this way the air-leak can be sealed and there should then be no difficulty in inflating the lung to its full capacity. The thorough exploration of the lung and injured side of the chest while the breathing function of the organ is going on ought also to facilitate the sterilization of the pleura if this shows evidences of contamina-

tion; foreign bodies could be removed and the best points for drainage recognized. Of course, ordinary free drainage would favor the return of a partial pneumothorax, even after anchoring the lung to the parietes and closing the external wound; but this can be avoided in septic conditions (which are exceptional at the time when these interventions are called for) by attaching a canula or glass tube to a receiver connected with an aspirator (*e. g.* Potain's apparatus). The drainage by progressive aspiration would be sufficient in this way to meet indications until adhesions would have had time to form and thus prevent any further risk of pneumothorax if freer drainage should be ultimately required.

As to the precise method of operating, little need be said; the operations must vary with the situation, extent and character of the wounds. Reclus presents this side of the problem very clearly when he says: "The rules of surgical technique need never trouble the surgeon. The surgeon is taking his chance of what he will find, and his procedure will be according to the exigencies of the case. I will only say that if he has to deal with a wound of the lung, he must make his opening into the chest-wall very free, or he will never find the bleeding vessels. Delorme's temporary resection does this for us, but such heroic treatment is full of danger when the patient is wounded, feeble and drained of blood, and the surgeon will have to steer between Scylla and Charybdis, neither to be too sparing with the incisions lest he fail to find the source of the hemorrhage, nor to cut too freely lest the patient come in danger of death from shock."

We believe, however, that the danger of losing valuable time by an insufficient opening is greater than that of inflicting shock, unless it be in the posterior region of the chest, where the ribs are thick and the intercostal arteries are very large. But as a fenestrum in the lateral aspect of the thorax should suffice to expose the entire external surface of the lung, and the internal also, if the organ is lifted up, and dragged out of the chest, it is not likely that posterior thoracotomies will ever be required or attempted. In this region it is comparatively easy to control the bleeding from the

intercostals with hemostats, and to cut the osteoplastic flap quickly with a sharp costotome. It is very probable that the bleeding in the lung will always be best controlled by suturing with an absorbable material, chromicized or cumolized catgut being preferred. In view of the ease with which the lung tears, and also for fear of puncture-leaks, a round milliners needle or intestinal needle should be used. Thus far hemostasis has been attempted only by packing with gauze, three cases (Quenu, Michaux, DaCosta); by tying the bleeding surface and cutting off the pedicle above the ligature (Omboni); by sutures (Delorme and Robert, Turetta, P. Ferraresi). It is possible that the thermocautery may also be useful, but on this point, as on many others, the surgeon must act according to his convictions and opportunities.

In making these suggestions I again wish to be understood as not underrating the gravity of the circumstances in which these operations are performed. I recognize only too well that there will ever be a certain percentage of penetrating chest wounds which will inevitably end in death, no matter what the resources of surgical science and art may be, just as there will be others that will recover without treatment, with the simplest mode of treatment, and even in spite of treatment. But there is an intermediate zone, occupied by those who are not killed outright after these injuries, and those in whom it is evident from the first that they have not sustained a mortal injury; it is this doubtful zone which will furnish the battle-ground in which it will be possible for timely and skilful intervention with the new aids here described—to tip the balance so that some will live who would otherwise die.

XX.

APPENDIX.

SYNOPSIS OF REPORTED CASES OF WOUNDS OF THE LUNG TREATED BY DIRECT EXPLORATION AND LOCAL SURGICAL TREATMENT.

OBS. 1.—*Omboni* of Cremona operated in 1885 (Boll. del Comit. Cremon. 1884, IV, p. 228). A young man, aged 20, shot himself with a revolver in the left side of the chest; extensive hemothorax and great collapse followed. An incision 5 inches long was made in the third intercostal space through which a great quantity of blood escaped.

The left lung was partially drawn out of the wound and a perforation in the lower edge of the upper lobe of the lung was discovered. The wounded portion was secured with double catgut ligatures passed above it and excised. Another bleeding point in the lower lobe was recognized: this was closed with catgut sutures, but one of them gave way and finally a ligature was applied and the wounded area excised. The patient did well at first; but the wound suppurated and he died on the seventh day from pyemia, caused by defective drainage.

Obs. 2.—*Delorme and Robert* (Congres Français de Chirurgie, Comptes Rendus, 1893). An army officer attempted suicide by stabbing himself four times over the heart with an amputating knife. Immediately taken to the Hospital Val de Grace, where the wound was dressed antiseptically and closed. He grew worse for two days, with signs of hemorrhage and exhaustion, when Delorme and Robert decided to interfere. An osteoplastic flap was raised: three wounds in the lung were recognized, also two of the pericardium. All were closed with sutures and air and blood ceased to escape. Death from surgical anemia one-quarter of an hour after the operation.

Obs. 3.—Reported by L. de Sanctis and I. Feliciani (Ospedale della Consolazione, Rome). La Riforma Medica, page 99, 1894. Anno I. Man, æt. 43, was admitted to the hospital on June 26, 1894. Four stab and punctured wounds were recognized, all penetrating in the right chest. All the wounds were bleeding freely, and there were signs of pneumothorax. Fearing that the diaphragm had been injured, and observing that the patient was growing worse from hemorrhage, the authors decided to operate. Chloroform. The most important wound was recognized in the seventh right intercostal space and was enlarged. A large flap, including 5 to 6 cms. of the rib which had been fractured or cut through with a knife, was elevated. A bleeding intercostal artery was ligated. Through the large opening a considerable quantity of blood was discharged from the pleura: notwithstanding the free opening of the pleura, the atelectasis of the lung was not very marked. The diaphragm was found uninjured. A linear incision 2 cms. was easily discovered in posterior surface of lung, which was bleeding copiously. The lung was seized with forceps and the wound explored, and was found to be 3 cms. deep. The wounded lung was dragged to the pleural opening and closed with three deep silk sutures. All bleeding stopped. The pleural opening sutured. The patient very much collapsed; breathing very bad; pulse very thready and small; aroused finally by stimulating treatment, hypodermics of caffein and ether, and ultimately recovered. On the 31st of July, about a month after admission, he was discharged practically well.

Obs. 4.—*Quenu* (Congres Français de Chirurgie, Sem. Medicale, November 13, 1895). A young man, age 19 years, admitted at the hospital with a penetrating wound of the seventh left intercostal space. It was sutured. Extreme pallor and signs of large pleural effusion followed. Next morning eighteen ounces of almost pure blood were aspirated from the chest. One week later three pints of almost pure blood had to be drawn off. The next day, or about nine days after the injury, the condition growing progressively worse, Quenu decided to interfere. He removed the stitches, enlarged the wound and resected the seventh rib. Several clots were removed from the pleura and iodoform pack was pressed against the wound, and left *in situ*. No more hemorrhage occurred; the cavity filled up very quickly and the patient was discharged in a fortnight.

Obs. 5.—*Michaux*, (Congres Français de Chirurgie, Comptes Rendus, 1895, and Sem. Medicale, October 22, 1895). A young man, aged 18, shot himself with a revolver in the left side of the chest about an inch above

the nipple. The wound was closed with collodium. In twelve hours profuse hemothorax in corresponding pleura. Condition grew decidedly worse during the day and on the evening of the second day Michaux concluded that it was necessary to interfere. Three to four inches of the seventh and eighth rib were resected in the neighborhood of the wound. Nearly a pint of blood and clots escaped and a wound was discovered on the inner surface of the lung below its root. Bleeding was now not very free and the operator fearing that he would obliterate an important vessel by applying a forceps near the hilum simply plugged the wound with iodoform gauze, bringing the end of the strip out of the chest. Two large drainage tubes were left *in situ* after suturing the wound. Slight suppuration; perfect recovery.

OBS. 6.—by Dr. Ferraresi (Paolo). A young man aged 26 was stabbed in the eighth interspace, left axillary line; great shock and hemorrhage. Osteoplastic thoracotomy including resection of 6 cms. of eighth rib, a wound in the diaphragm measuring 6 cms. length, was enlarged to 14 cms. to facilitate exploration of stomach and intestines, which it was feared had been wounded. Careful examination of these organs (which were dragged out of the thoracic wound) showed that they had escaped injury. A wound of the lung was recognized and sutured, but the bleeding which most seriously endangered the patient's life came from the spleen; the wound in this organ was readily recognized and the bleeding controlled by suture. The edges of the divided diaphragm were then carefully united by suture after thoroughly cleansing the pleura. The chest wound was finally closed. The patient was almost *in extremis* but finally recovered.

This is one of 27 remarkable cases of stab wounds of the diaphragm treated by direct transpleural exploration and suture, of the diaphragm and of other organs, operated by Roman surgeons, and collectively reported by Prof. C. Postemski at the XIth, International Congress held in Rome, March 29, 1894, (*Atti*; Vol. IV, Roma 1895.)

OBS. 7.—Operator, Dr. Virdia, quoted in *La Cura Chirurgica delle Pneumorrage Traumatiche*, per Dott. Prospero Guidone, *Riforma Medica*, pp. 458-465, 1896, anno XII, Pt. 2. A patient (neither age or sex stated) suffering from a stab wound of the lung in the seventh right intercostal space; great hemorrhage; musculo-cutaneous thoracotomy, including resection of two ribs; bleeding wound in the lung closed by suture; recovery.

OBS. 8.—Operation by P. Guidone (same reference). Male, æt. 39. Was twice stabbed in the back. One wound in the left lumbar region; another in the ninth intercostal space, on a level with the left scapular line, 4 cms. long. The patient was brought to the hospital one hour after injury: condition verging on collapse. The wound in the lumbar region was found to involve only muscular layers. The wound in the intercostal space was enlarged and the index finger introduced failed to detect any injury to the diaphragm, as had been feared. Blood was flowing copiously from a very deep and long gash in the inferior lobe of the lung. As the operator was about to resect a rib in order to gain easier access to the bleeding surface, the patient sank into a syncope condition which for the moment appeared to be fatal. All effort to suture the lung was abandoned and the pleura and wound in the lung were hurriedly stuffed with one yard of sublimate gauze. The external wound was simply covered with antiseptic dressings without suture and the patient put to bed apparently in dying condition. Stimulating treatment freely applied; hypodermics of ether and caffeine, under which the patient revived. The gauze was removed on the seventh day, and on the fifteenth he was discharged.

OBS. 9.—A. Turetta (*Arch. ed Atti d. Soc. Ital. di Chirurg. Roma, 1896, X, 140-42*).

In this report the suture of the lung was only incidental, considered in connection with graver lesions. The case is one of punctured or stab wound of the eighth left interspace (male, *æt.* 30) which penetrated the lung, the diaphragm and the stomach. Food and gastric contents were found in the pleural cavity. The ninth rib was resected to expose the wounded surface and facilitate the suture of the lung (the lower edge), the diaphragm and the stomach. Laparotomy was then performed to irrigate and flush out the upper peritoneum and soiled surfaces in the neighborhood of the stomach. Great exhaustion, but final recovery, after septic pleurisy. Very little is said of the wound of the lung except that it was sutured with finest silk, the operator evidently regarding the gastric and diaphragmatic wound as a much graver consequence.

NOTE.—This operation was performed in 1893.

OBS. 10.—Da Costa, J. C. (*Annals of Surgery XXVII, No. 1, January, 1898*). On June 5, 1897, George P., *æt.* 18, was shot in the back with a revolver. He was shot at a distance of 100 yards, and fell unconscious. When seen by physician he was in collapse. Little bleeding from the wound. He rallied a little but again grew worse gradually. Eleven days after injury he was seen by Da Costa. Diagnosis of hemothorax from a wound on level with spine of fifth dorsal vertebra, $6\frac{1}{2}$ cms., to the right of the vertebral spine. Ordered rest, but extreme exhaustion and signs of progressive secondary hemorrhage decided in favor of immediate operation. Ether-narcosis coincidentally with intravenous solution. The improvement in the general condition was rapid and decided. During the operation two pints of saline solution were thus administered, and to this infusion the preservation of life is undoubtedly due. After confirming the diagnosis of hemothorax with the needle a U-shaped flap was made with six inches of fifth and sixth ribs included. Opening the pleural sac followed by a furious gush of blood. Violent cough began and the wound was partly plugged to prevent blood escaping too rapidly. No clots. The collected blood discharged from the pleura measured one gallon and half pint (136 ounces). Lower lobe of lung was found lacerated, sloughing and bleeding profusely. Ligatures and sutures would not hold. Catch forceps failed to control bleeding. The hemorrhage only stopped when the operator grasped the bleeding surface with his fingers. To have simply packed gauze against the bleeding point would have done no good, as the lung would have been pushed away. While the lung was being compressed by the fingers, the entire pleural sac about it was filled with sterile gauze. This afforded a base of support. The fingers were now relaxed and iodoform gauze was forcibly packed against the bleeding surface. The sterile gauze previously introduced kept the lung from receding, and the gauze in the wound controlled the bleeding. The ends of the pieces of gauze were made to project from the wound and the flaps of the soft parts were sutured in place. Forty-two square feet of gauze were used to pack the pleura and were allowed to remain until the fourth day. There was profound shock; for five days delirium, but by end of first week the patient was clearly out of danger. The lower lobe of the lung sloughed off, and was removed piecemeal. This case is remarkable and unique in many respects. Especially because hemothorax and general bad condition were due to secondary hemorrhage. Other cases reported were instances of primary hemorrhage.

The advantages of saline solution and the successful hemostasis by

the special method of packing are conspicuous among other interesting points.

If we sum up the results obtained in the ten cases reported here, we will note only two deaths in the whole series, or 20 per cent. mortality. Of course, this is only the *reported* mortality, we do not know how many *unsuccessful* cases have not been reported. Usually only the successful cases are reported; the failures are buried and rarely referred to, in print. Nevertheless, the showing for stab wounds is encouraging, though all the reports confirm the extremely desperate character of the injuries. As to the methods employed we will notice that in one (Omboni) the bleeding areas were circumscribed by sutures an excised. In five the wounds were sutured (Robert & Delorme, De Sanctis & Feliciani, Virdia, Turetta, P. Ferraresi). In four the wounds were plugged with gauze (Michaux, Quenu, Guidone, Da Costa).

XXI.

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